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ABSTRACT

This 4-year project located in Rockford, Illinois, tested the minicomputer-controlled interactive instruction by two-way cable against more traditional learning situations during a 12-lesson course in prefire planning administered to the city's fire department. This volume describing the development and implementation of the cable television communication system and its effectiveness in urban administration presents a comprehensive account of all phases of the experiment, including cognitive performance and affective results, as well as a description and discussion of the two-way technology and its performance, a cost analysis for the training program, and public policy implications. (Author/SAO)

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VOLUME II

MICHIGAN STATE UNIVERSITY-ROCKFORD TWO-WAY CABLE PROJECT

System Design, Application Experiments and Public Policy Issues

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FINAL REPORT

NSF Grant No. APR75-14256

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Department of Telecommunication
Michigan State University
East Lansing, Michigan

June 1978

Contributing authors to this volume also include: James Wright, Steven McVay, John Pavlick, Micky Stepanoff, Michael Sheridan, Joyce Emery, Eric Smith, Michael Gerbett, Robert Yadon, Michael Wirth, Judith Sarno.

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It will be impossible to acknowledge all persons who have contributed to this project. However, it is essential to name a few.

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The Rockford Fire Department is remarkably innovative. The Department has been a willing and enthusiastic partner to Michigan State University. Chief James Cregan, Deputy Chiefs Doug Bressler, Robert Quist, Paul Patton, and John Jung, Dominic Guglielmo, Richard Connell, Howard Stewart, Ronald Crow, Vincent Collins, Nancy Johnson, Marge Comstedt, to name only a few, have been most helpful. We are also sincerely grateful to the 208 firefighters in Rockford who participated in the experiment. They were very patient with the tests and waves of questionnaires. The men of Station Number Seven, outside the cable service area, worked with us in the formative evaluation stages, responding to pretests and commenting on the initial videotape of each lesson.

Rockford Cablevision, Inc. assumed a major burden and a good deal of the risk in making the system work. Earl Hickerson, President, committed capital and personnel to the two-way communication system. The original engineering of the system was carefully and imaginatively designed to accommodate two-way services, long before the industry understood and accepted two-way. James Wright was primarily responsible and worked very closely with the Michigan State University staff through the entire project. John Bowers, James Thomas, Frank Sheley and Dean Deyo also worked closely with the project staff.

Crucial engineering support was provided by Stevens McVoy of Coaxial Scientific Corporation. His concept of an area multiplexed, switched return system was vital to the Rockford experiments and has been an important factor in the industry-wide renewed interest and development of two-way cable. Allen Fulmer also made major contributions to the system design and function. Tim Dunning was a principal troubleshooter for the system.

The Michigan State University field office in Rockford was responsible for the research, writing and production of the 12 television lessons and the administration of the experiment. These tasks were accomplished exceptionally well by John Pachuta, the Field Director, and Michael Sheridan, the Executive Producer. Television graphics were ably provided by Karyl Bauman. These people may take credit for the teaching effectiveness of the videotapes and the favorable response by the firefighters. Large scale field experiments are always difficult to manage. The fact that this one went relatively smoothly is attributable to the diligence of this staff and their effective liaison with the Rockford Fire Department.

At Michigan State University, several students in the Mass Media and Communication Ph.D. programs and in Computer Science were major contributors. Jayne Zanaty became the principal computer programmer, wrote much of the technical and computer sections of this report and was responsible for the computer documentation in Volume III. She also coordinated the medical education demonstration for the National HURA (Health in Underserved Rural Areas) Conference. Nicky Stoyanoff coordinated the pretesting and formative evaluation used in the planning of the videotapes, and in the experiment, the instrument design and collection and analysis of data. Lee Thornton did much of the background research for the firefighter training experiment and was responsible for a number of suggestions that were incorporated in the design. Robert Yeaton helped to write some of the technical papers on the project and worked on future applications and technology. He also worked with Mike Wirth who was responsible for the basic research on costs and the cost analysis. Jim Wollert and Brian Fontes worked tirelessly on the original design proposal and followed up on the exploration and development of additional applications of the two-way technology. Judith Saxton was one of the researchers on public policy issues. Jack Wakschlag and Mark Miller both were active participants in the experimental design phase of the project. Michael Gorbutt was one of the designers and the builder of the timecode interface and video switcher controller.

Dennis Phillips began the system design and computer programming for the project while the equipment was still in East Lansing. Eric Smith also worked on the system in East Lansing and moved with the equipment to Rockford to complete the computer programming and testing after installation. He also created the programs to accommodate the University of Michigan two-way experiment in the Rockford Public Schools.

Robert Schlater, Chairman of the Telecommunication Department, and Erwin Bettinghaus, Dean of the College of Communication Arts and Sciences willingly accepted the additional administrative burden associated with such a large project, and found the means to compensate for the loss of faculty and graduate students to the project. John Abel and Donald Montgomery, Michigan State University faculty members, were invaluable to the project at crucial points, while they were on campus. Kent Gustafson, of the Michigan State University Instructional Development and Telecommunication Services unit, served the project well as a consultan in the instructional design area. Sanford Lanchner, a co-investigator in the earliest Michigan State University-NSF cable study, bears a major responsibility for the staff interest in broadband communication. He introduced a number of concepts that were further developed in this study.

In addition to her other duties, Becki Henry kept the books, handled personnel matters and travel and did the manuscript typing. These tasks were immensely complicated by the fact that the project staff was in two locations, separated by 300 miles, and in several departments of the University.

Heather Thiessen was the principal proofreader in the preparation of these volumes and has managed the associated dissemination activities.

From the crude, much-edited original manuscripts, Phyllis West (typesetting) and Frank Cascarelli (layout), Michigan State University Printing, created what we believe to be very readable and attractive reports.

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Chapter 1

Introduction and Abstract of Findings

Overview

This volume describes the development and implementation of a two-way interactive cable television communication system and its effectiveness in urban administration.[1] The four-year National Science Foundation experiment, located in Rockford, Illinois, tested the minicomputer-controlled interactive instruction of two-way cable against more traditional learning situations during a 12-lesson course in prefire planning administered to the city's fire department. Presented here is a comprehensive account of all phases of the experiment itself, including cognitive performance and affective results, as well as a description and discussion of the two-way technology and its performance, a cost analysis for the training program and public policy implications.

Since the scope of the experiment includes areas of interest to urban administrators and fire officials, cable system operators, computer scientists and engineers, educators and communication specialists, the chapters will be of differential interest to specialists. Chapter 1 presents the background on this project, descriptions of other operational two-way cable systems and general reference to the literature identifying other experiments and demonstrations. Chapter 2 describes a model for the evolution of two-way communication systems with small matching steps in technological development and service implementation. Chapter 3 discusses firefighter training, prefire planning and the format created for the two-way interactive lessons. Chapter 4 is devoted to the lesson development cycle including content research, pretesting, scripting, production and formative evaluation. Chapter 5 describes the minicomputer and other cable headend equipment and the software necessary to scan terminals and automate the instructional system. The cable system configuration to accommodate the two-way communication and special system distribution plant design characteristics are outlined in Chapter 6. Chapter 7 presents the preparation for the experiment, which is described in detail in Chapter 8. Chapter 8 also includes the results of the experiment. Chapter 9 is the cost analysis. It includes the cost of two-way cable training compared to other methods as well as the general value of training all firefighters to participate in the prefire planning process. The chapter concludes with estimates of the incremental cost of adding two-way communication to a one-way cable system. Chapter 10 is an analysis of the public policy issues raised by the introduction of two-way communication in cable. Chapter 11 is a postscript to the experiment, indicating follow-up activities in the fire service and other two-way communication applications that have emerged from the original project.

1. This report is based upon research supported by the National Science Foundation under Grant No. APR75-14386. Any opinions, findings and conclusions are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Research Results Summary

We believe the research reported here supports the following conclusions:

(1) Digital return communication from the feeder lines is feasible in a single cable system.

(2) A switching system is effective in limiting return system noise and signal ingress.

(3) De-ingressing the system for return communication improves system performance in both directions.

(4) No extraordinary system maintenance is required for two-way communication, if the system is properly designed at the outset.

(5) Two-way, interactive cable instruction is more effective than comparable one-way television in teaching cognitive information. The two-way advantage in learning remains after six months.

(6) Two-way, interactive television, where respondents have individual response capability and personal feedback, is more favorably assessed than one-way television and is considered equal to live instruction by the participants.

(7) Automated, prepackaged two-way cable television is administratively more efficient and reliable than one-way television systems for record-keeping.

(8) The cost of two-way television, in most circumstances, is lower than auto-tutorial or lecture methods.

(9) Two-way cable television is more expensive than one-way television, but in large scale training systems, the difference in dollars is very small.

(10) The cost of prefire planning as a collateral duty of all firefighters trained in building survey and preplanning is much less than the cost of prefire planning by full-time specialists.

(11) Large cable systems (10,000 subscribers or more) are more likely to find two-way service profitable.

(12) The cost of operating a two-way cable system is more likely to impede initiation of two-way service than cost of construction.

(13) The potential for public service use of two-way cable services places a major burden on franchise authorities and cable systems in determining when to implement two-way service.

(14) The responsibility of the franchise authority in two-way cable may extend to development and aggregation of public services, particularly in public safety and education, and in monitoring upstream spectrum management.

Origins of the Michigan State University-Rockford Project

This project developed in response to the National Science Foundation intent to "support a series of social experiments in the application of two-way cable telecommunications to the delivery of urban social services, and to urban administration." (1) (Notes are located at the end of each chapter.) Phase I was to design application experiments; Phase II, to carry out experiments selected from the design submissions. We began with an exhaustive inventory of urban administration and social service needs in Rockford, Illinois. (2) The Rockford site was chosen because the cable system had been engineered to accommodate two-way cable and the city government was very much interested in public service applications.

In the design study, five applications were submitted as the most promising for developing the two-way cable system technical design and exploiting the two-way capability in pressing social and urban administrative needs. These included plans to:

(1) train firefighters;

(2) detect and correct learning disabilities among preschool-age children at the earliest possible stage;

(3) increase awareness of and access to information about major social services available to citizens in a community;

(4) increase efficiency in the administration of law enforcement, legal and court systems of the community; and

(5) facilitate, through teleconferencing, intercultural sensitivity in the racial integration of the public schools while increasing academic opportunities in math and science. (3)

Of the five experiments designed under the original grant, the firefighter training application was selected for funding. The others remain as examples of services which could be delivered by two-way cable. The technology described for the firefighter training experiment is directly applicable to three of the other services and has been thoroughly tested in two years of operation. The last application, teleconferencing between schools, involves no novel technology and has been demonstrated on several occasions by Rockford Cablevision.

Background on Two-Way Cable

The history of two-way cable is well-documented in other volumes. "Cable Television: Strategy for Penetrating Key Urban Markets," by James D. Scott, describes the first experiments and commercial ventures. (4) The early two-way technology and its attempted application in the U.S. is thoroughly discussed in Richard Veith's *Talk-Back TV: Two-Way Cable Television*. (5) Worldwide experiments in two-way cable are outlined in *Two-Way Cable Television: Experiences with Pilot Projects in North America, Japan and Europe*. (6) Peg Key, through the Cable Television Information Center, with National Science Foundation support, analyzes the applications of two-way cable in the public sector. (7)

In inventorying two-way cable applications, reference should also be made to the Rand Corporation's Spartanburg, South Carolina project (8) and the New York University-Alternate Media Center project in Reading, Pennsylvania. (9) In addition to the present Michigan State University applications, the two-way system in Rockford is employed in a teacher development program in the Rockford Public Schools. The experiment is directed by the University of Michigan. (10)

The two major operational two-way systems, which have not been fully described in generally available literature, are the TOCOM, Inc., system in Woodlands, Texas and elsewhere, and the Coaxial Scientific Corporation Teleticnema system in Columbus, Ohio. A third system, Warner Cable Corporation, also in Columbus, brings the resources of a major communications conglomerate into the field for the first time. All three enterprises are described

in this volume in an effort to complete the record of earlier work provided in the literature described above. These three systems are important because, along with the Rockford system, they represent the most advanced, practical, two-way technologies, and, for all the experimental efforts described in the literature identified above, the only currently operational two-way systems.

Because the technology for the Coaxial Scientific Corporation Teleciнema system is the forerunner of the Rockford two-way system, it is described in detail in a later section. Teleciнema is a four-channel pay per-program movie and sports service associated with a CATV system.

TOCOM, Inc., of Dallas, Texas, was one of the earliest innovators in two-way cable system design and application. There are currently two systems available, allowing an operator to upgrade his system on a demand basis. The smallest system is the TOCOM III-A which serves up to 2,000 home terminals. It offers up to 36 channels of standard TV reception, plus fire, intrusion and medical alarm services. In addition, the system can handle per-program pay TV, as well as opinion polling and power load management where desired. The larger TOCOM III-B utilizes III-A units throughout the plant as remote data systems, which act as polling stations for sub-areas of the plant and are controlled by a larger minicomputer.

Each home terminal consists of a digital transmitter and receiver with its own unique hardwired identification. Every few seconds, the central data system requests the alarm status of each of the 2,000 home terminals within its area. The system is designed so that monitoring service may be offered to subscribers regardless of whether they elect the basic CATV service. For those who want the basic CATV service, control of the converter connected to the home terminal is accomplished via a hand held unit which incorporates channel select capability as well as a response mode for interactive education polling. (11)

The Warner Cable Corporation system in Columbus has the potential to serve 100,000 households. The addressees are partitioned into groups of no more than 16,000. Each group is fed independently by the headend. Noise in the return trunk is controlled by a gating system, similar to that pioneered in the cable industry by Coaxial Scientific Corporation,[1] which limits the number of terminals with a clear path to the headend at any given time. The switches are located at each bridger amplifier, serving up to 600 subscribers. The terminal has 10 channel selection buttons that are used in combination with three other buttons to provide 30 channels; one bank for over-the-air television, the second bank for "community" channels (e.g., local news and information, children's programs) and the third for per-view pay programs (e.g., movies, sports, instruction). Responses in polling and instructional programs are made on five buttons independent of the channel selection buttons. (12)

1. During the period of the experiment this company was also known as Broadband Technologies, Inc.

Notes — Chapter 1

(1) National Science Foundation, "Program Solicitation, Design Studies for Experimental Application of Two-Way Cable Communications to Urban Social Service and Administration," Research Applied to National Needs, Division of Social Systems and Human Resources, Closing date, April 15, 1974.

(2) Thomas F. Baldwin, Bradley S. Greenberg and Thomas A. Muth, "Design Study for Urban Telecommunication Experiments," Michigan State University, April 13, 1974.

(3) Thomas F. Baldwin, Bradley S. Greenberg, Thomas A. Muth, "Experimental Applications of Two-Way Cable Communications in Urban Administration and Social Service Delivery," College of Communication Arts and Sciences, Michigan State University, January 2, 1975. Prepared under Grant No. SSH74 20963 A01, National Science Foundation.

(4) James D. Scott, "Cable Television: Strategy for Penetrating Key Urban Markets," Michigan Business Reports, No. 56, 1976.

(5) Richard Veith, Talk-Back TV: Two-Way Cable Television, (Blue Ridge Summit, Pa.: Tab Books, 1976).

(6) W. Kaiser, H. Marko and E. Witte, eds., Two-Way Cable Television Experiences with Pilot Projects in North America, Japan and Europe, (Berlin: Springer-Verlag, 1977).

(7) Peg Kay, Social Services and Cable TV, NSF/RA-780101, (Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1978).

(8) William A. Lucas, "Spartanburg, S.C.: Testing the Effectiveness of Video, Voice and Data Feedback," Journal of Communication, Vol. 28, No. 2 (Spring 1978), pp. 168-179.

(9) Mitchell L. Moss, "Reading, Pa.: Research on Community Uses," Journal of Communication, Vol. 28, No. 2 (Spring 1978), pp. 180-187.

(10) Peter Clarke, F. Gerald Kline, Hanno Schumacher and Susan Evans, "Rockford, Ill.: In-Service Training for Teachers," Journal of Communication, Vol. 28, No. 2 (Spring 1978), pp. 195-201.

(11) "Bankers See Two-Way Cable Coming on Strong in '78," TV Communications, May 1978, pp. 20-27.

(12) "Warner Tackles Technological Giant in Change to Two-Way," TV Communications, April 1978, pp. 20-27.

Chapter 2

A Developmental Model for Two-Way Cable Technology[1]

In responding to the National Science Foundation's commitment to experiments in public service applications of two-way cable technology, we recognized an obvious need to fit the firefighter training experiment into a larger developmental context for two-way cable. Therefore, we created a systematic model which carefully times and integrates the technical capability of various broadband communication systems with economically viable communication applications on a step-by-step evolutionary basis.

Communication Capabilities of Coaxial Cable

We began with a description of the particular communication capabilities and potentials of cable. A coaxial cable system, by its physical nature, is most efficiently used as a means of disseminating information from a single point, or source, to a large number of points, or users. Conversely, it may also be used as an efficient means of transporting information from a large number of remote sources back to a single point. A cable system is used least efficiently in point-to-point communication. Unlike the telephone which has the capability of switching signals from one telephone station (office, home, phonebooth) to another, most cable systems are not switched, but rather designed in a branching configuration. Because of this distribution characteristic, discussion of two-way cable return systems is generally in terms of digital signals generated by push-button response pads.

A typical cable system resembles a tree, with a network of trunk cable and trunk amplifiers delivering full video signals from the headend, or transmission center, to bridger amplifiers. These amplifiers then transfer the signal to a system of feeder cable and feeder amplifiers. The feeder system delivers the signal to the tap-off units, and then by service drops into the subscriber's home. Interference problems in the feeder and drop portions of the cable system make the transmission of video signals from the subscriber's home to the headend (i.e., upstream) impractical. Hence, return video signal service is possible only in the trunk portion of the system, while data return signals are workable in the feeder portion. (An aural return signal service via coaxial cable would seem to be of limited value because of the existing service provided by telephone.) This leaves the most practical design for the upstream portion of a two-way cable system as video and high-speed data by trunk cable, and data only by the feeder cable.

The next consideration is the allocation of the limited bandwidth in the cable system to forward and return channels. Despite the popular characterization of cable as a medium of abundance, there is a very real limit to the available bandwidth in the cable system. The use of any available frequency must be considered in terms of both opportunity cost and the cost of additional equipment necessary to support it. This demands careful planning and spectrum management.

It should be obvious that an increase in the bandwidth allocated to return signals will cause a decrease in the bandwidth available for forward video signals. Fortunately data signals generally require considerably less bandwidth than video signals, and can be multiplexed by time, frequency and area. An optimal allocation seems to be approximately 250 MHz for forward service use channels and only about 25 MHz for the return service. More details about the basic two-way system in each stage of its evolution will be provided later.

Applications of Two-Way Cable

One of the greatest obstacles to the continued development of two-way cable technology has been the attraction of necessary investment capital. Investors have not seen sufficient return from any application of the current technology to justify the risk. The exploitation of two-way cable applications has failed because each application has been considered in isolation without a convergence of multiple applications for cost-sharing the two-way plant. Further, the two-way technology has never evolved as a synthesis of practical need and cost-efficient technology. Two-way has been considered in terms of some end-state of both technology and application. The step-at-a-time approach has not been followed.

1. This chapter was written principally by Martin Block. D. Stevens McVoy, James Wright, John Ruhenberg and Thomas Baldwin.

Unlike other communication media, two-way cable has captured the interest of the public sector early in the developmental stages. Whatever the future of two-way communication, there is almost no doubt that the public sector will play a prominent role, and that two-way cable will involve applications from both public and private sectors. A wide variety of public sector applications for the two-way cable technology has been funded by the National Science Foundation and other federal agencies. These are described in the previously mentioned volume, *Social Services and Cable TV*. (See Note 7, Chapter 1.)

Private sector applications of two-way cable technology have lagged behind because of limited research and development money in the relatively small cable industry. Further, the industry has been preoccupied with more immediately profitable commercial applications such as per-channel pay entertainment. The private sector application receiving the most attention is per-program pay TV, with the previously discussed Teleciniema and Warner systems the only large scale operational examples. For the future, other private sector applications may include marketing and advertising research, in-home shopping and in-home monitoring and surveillance services. Among the suggested marketing and advertising research applications are television audience measurement, television advertising copy pretesting and posttesting, television program pilot testing, package design tests, advertising concept tests, product purchase behavior measurement and various other questionnaire-oriented research including awareness and preference measurement. Among the in-home shopping applications are electronic supermarkets and catalogs using special dedicated channels and interactive advertising. Among the in-home monitoring and surveillance applications are heat and smoke detectors, intrusion alarms, tamper alarms, electric, gas and water metering, electric load management, CATV and pay-TV control. Also in the future are applications such as electronic mail and news delivery, opinion polling and many more.

While the list of suggested applications for two-way cable can be greatly expanded beyond the general categories mentioned here, such lists almost always consider two-way cable technology as fully developed for multiple services. Rarely is two-way cable technology considered as an evolutionary process, with some applications preceding others as the technology and demand develops. It should be obvious that some applications of two-way cable, such as per-program pay TV, are possible given the state of the technology today, and other more complex applications, such as power load management, require continued technological development.

In order to simplify the relationship between the technological evolution of two-way cable and the applications, a classification scheme of six categories will be used. Ignoring all applications which primarily involve communication in an institutional framework, such as high speed data communication between banks or upstream video transmission from city hall to the cable transmission center, and concentrating on applications involving communication with only digital return from homes, the classification scheme includes the four private sector applications already discussed—pay entertainment, shopping services, marketing research and monitoring services—plus categories in education and community information. The education category includes the in-service training applications in an in-home setting along with various adult education applications. The community information category includes the electronic mail delivery application, automated newspapers and related services, the public forum concept and the social service information and referral system. (See Figure 2-1.) The next task is to consider the evolutionary steps in the development of two-way cable technology.

The First Generation

The first generation in the proposed model for two-way cable system development was designed for a per-program pay TV system in Columbus, Ohio, and represents the important first step in the evolutionary process of two-way cable technology. The Teleciniema per-program pay TV system has been in operation since 1973. The system uses a home terminal which costs approximately $50,[1] and allows four channels of pay TV programming. The subscriber selects the appropriate channel, and is then billed only for the programs that are watched. This method of pay TV is different from per-channel pay TV where the subscriber pays a flat monthly fee for unlimited viewing on the pay channel.

A typical pattern for a per-channel pay TV system is very high initial subscription, probably around 40 percent of all cable subscribers, followed by a drop to around 25 percent after the first few months of service. Part of the explanation for this "churn" is the fact that people use only a small portion of the entire package of programs that is available, but feel they are paying for all of it—a sense that they are overpaying in relation to their usage.

The Teleciniema per-program system first tried charging subscribers only for the movies that were watched. Penetration was 80 percent and average monthly revenues were about $4, which was not

1. Different models of converters were modified for this purpose. $50 represents an average cost in 1973 dollars.

Figure 2-1. APPLICATIONS CATEGORIES AND THE GENERATIONS OF TECHNOLOGICAL DEVELOPMENT

enough to cover the costs of both the movies and the two-way system. In 1974, a $3 maintenance fee was added. This caused the penetration to drop from 80 percent to 40 percent, but the subscribers who dropped the service were those who did not watch many movies. Revenue averaged $8 per month among the remaining 40 percent.

In December, 1975, Telecinema began experimenting with other forms of programming in addition to theater films. Adult, children's and foreign films, nightclub performances and sports events were added. Average revenue increased to $11 per month.

The Telecinema system with over 5,000 subscribers was the first, and for many years the only, operating per-program pay TV system in the United States. The system was designed to solve the early technical problems found when attempting to use interrogation-response type terminals in cable applications—the high cost of the terminals and RF interference. Early cost estimates for in-home terminals ranged from $300 to $1,000, which was obviously too high to permit profitable operation. System maintenance costs, because of signal intrusion, were also estimated to be prohibitively high.

In order for two-way cable to become economically feasible, it was necessary to design a system around a reliable terminal that would cost approximately $50, and be part of a system that could be reasonably maintained. The solution was suggested after consideration of the types of multiplexing available for the return data signal generated by the in-home terminals. Time division multiplexing (TDM) offers the advantage of sharing a single frequency for all the terminals, but can easily be jammed by one malfunctioning terminal. The source of the trouble is very difficult to find. Frequency division multiplexing (FDM) solves the problem of terminal jamming, but if very many terminals are to be used, too much spectrum space is consumed. The solution is a combination FDM/TDM system which allows area multiplexing. It consists of the simultaneous transmission of groups of 100 to 200 frequency multiplexed terminals at different time intervals.

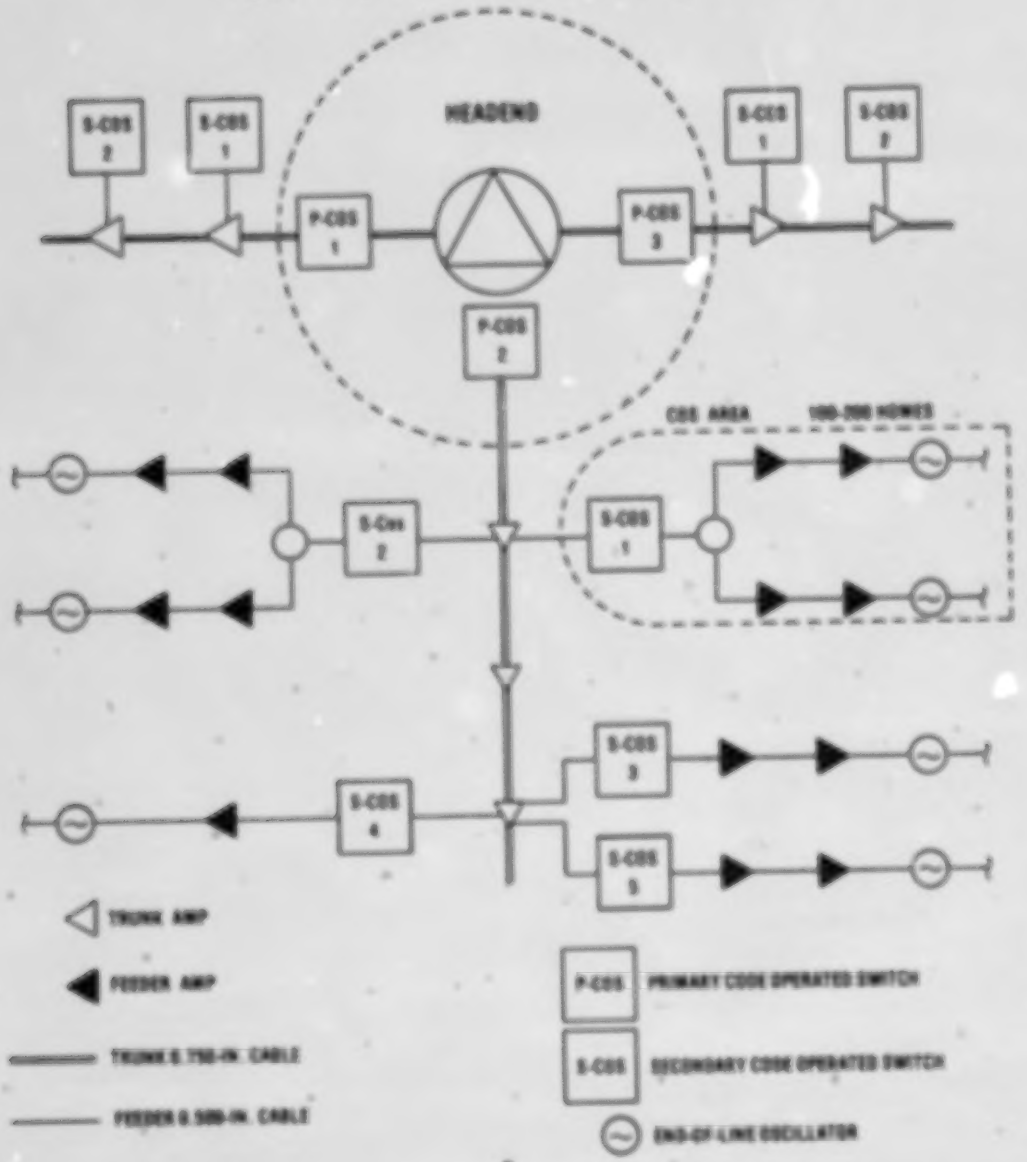
Area multiplexing is accomplished through the use of digitally controlled code operated switches (COS). Each COS consists of band-splitting filters which separate the downstream (50 to 300 MHz) frequencies from the upstream (5 to 30 MHz) frequencies. Downstream signals pass through the COS continuously without interruption, while the upstream frequencies are either passed or blocked as directed by a digital signal generated by minicomputer. This now allows an entire system of in-home terminals to

be scanned in small groups by activating and deactivating appropriate CODs. Placing a primary COS at each trunk and a secondary COS at each bridger amplifier makes possible the scan of an entire feeder branch which would normally consist of 100 to 200 homes. This design can be seen in Figure 2-2.

The use of the COS system allows for a much less expensive terminal than a typical interrogation-response terminal because a great deal of circuitry can be eliminated, including the RF receiver, decoder and address-recognition circuitry. A simple FDM terminal requires only a data encoder and RF transmitter circuitry, which, with the area multiplexing provided by the COS network, is all that is required. The home terminal consists of a cable converter which costs approximately $30 modified by the addition of a circuitry board containing only an FSK transmitter and data encoding circuitry, costing an additional $20. The terminal transmitter is assigned a discrete frequency in its own COS area, and transmits continuously. Each terminal transmits a 16-bit data word which indicates the status of the converter including the channel selected, whether the subscriber's television set is off or on and whether the security key on the converter is on or off.

A General Automation SPC-16 minicomputer manages the entire scanning operation through the use

Figure 2-2. FIRST GENERATION: AREA MULTIPLEXING



of special interfaces which control a CDS addresser and RF receiver. The minicomputer, operating in real time, routinely scans the system to collect data and generates viewing reports. Additional routines are available for terminal installation and system maintenance. Batch programs generate billing and other reports required by the cable operator.

System maintenance is easily accomplished through the combined use of the minicomputer and the CDS network to isolate interference and other problems. End of line oscillators (ELO) at the end of each feeder line add a unique carrier frequency for easy identification and help in balancing the system. The Columbus Telecinema system is maintained in this manner using one technician for approximately 200 miles of the plant.

The first generation two-way cable system is primarily designed as a per-program entertainment system. It does not allow for any interactive response, but only relatively simple monitoring of the status of the cable converter attached to the television set or an alarm wired to the cable. The only other feasible application for first generation technology is simple television audience measurement, since the system can be scanned at more frequent intervals than commercially available mechanical diary services and in a universe of households instead of a sample. The first generation, however, has clearly demonstrated both the technical and commercial viability of this technology, and paves the way for new generations.

The Second Generation

The second generation system was designed for the Michigan State University experiments in Rockford. Approximately one-third of the Michigan State University project investment has involved the development of the necessary two-way cable hardware and software required for the project. Additional investment has been made by Rockford Cablevision in constructing the necessary two-way plant in the city.

The major difference between the first generation (Columbus Telecinema) and the second generation (Rockford) is the addition of an interactive response capability at the terminal. Rather than providing only the capability for monitoring the status of a channel converter, the channel converter selection buttons can be depressed to transmit a return signal. This requires relatively minor modification of the first generation terminal, including addition of interactive channels and a transmit button. The additional channels allow the terminal to function not only as a converter but also as an interactive terminal. The transmit button, along with a timed LED display, insure that the subscriber responds only when desired and at intervals longer than the minimum scan. The second generation terminal requires a push-button type converter, which is not necessary in the first generation.

The transportation system including the CDS network and ELOs remains the same as before. The major difference in the second generation is in the minicomputer system. Since more processing is necessary with the possibility of a response in addition to the monitoring already required, the minicomputer needs to be augmented with extended core memory and sufficient disk storage to accommodate interaction. The primary addition to the second generation is not hardware, but rather computer software. The minicomputer software necessary to support second generation applications must not only perform the basic system scan routine and system maintenance, but it must also process response data in real time.

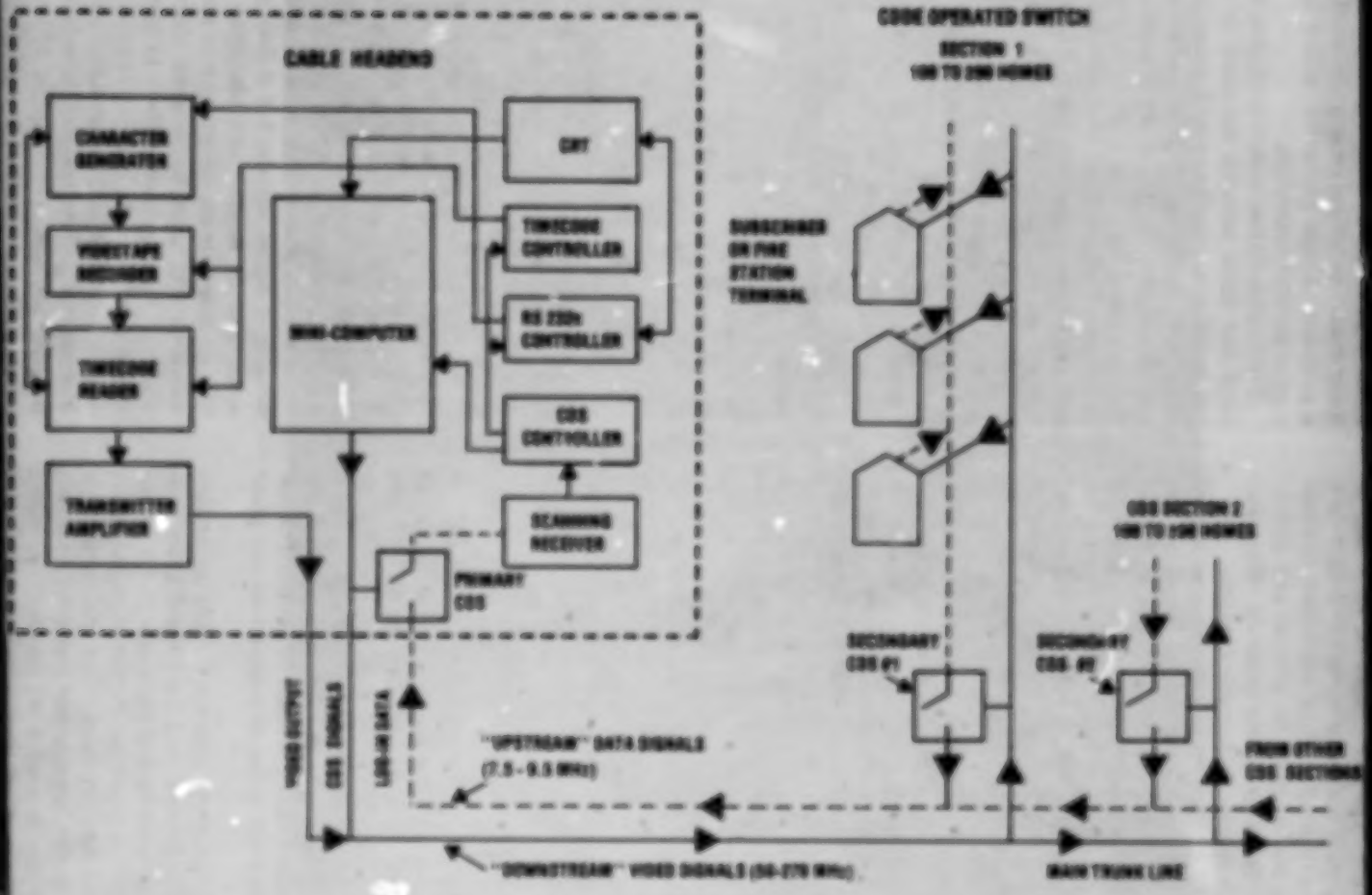
For training experiments, the coordination of downstream video signals and interactive response signals requires control of headend video equipment by the minicomputer system. This is accomplished by using computer-controllable character generation equipment, standard Society of Motion Picture and Television Engineers (SMPTE) timecode interfacing with all video tape equipment and standard process control input/output signals and relays to control the necessary video equipment. Thus, the minicomputer controls the entire two-way system. The second generation system is shown in Figure 2-3. It is described in more detail in Chapters 5 and 6.

The second generation terminal costs more than the first generation because of the need for a more sophisticated basic converter, and a small amount of additional circuitry and terminal modification. Depending on the quantity, second generation terminal costs range from $100 to $150.[1]

The second generation allows for upstream transmission of digital signals, but it does not allow the subscriber to receive individualized information; that is, downstream information is received by all televisions sets tuned to the same channel. It is not practical to allow subscribers to have the downstream portion of any interactive programming "on-demand"; rather such programming would be distributed on a prearranged schedule.[2] This is a serious limitation.

1. Without the channel converter, the cost of the unit would be reduced. A stripped-down terminal device would provide only interactive response generated from a simplified push-button pad, perhaps only four buttons, but would not provide any monitoring of channel converter status. This would limit application of the system to interactive response, eliminating per-program entertainment.

Figure 2-3. SECOND GENERATION: INTERACTIVE RESPONSES

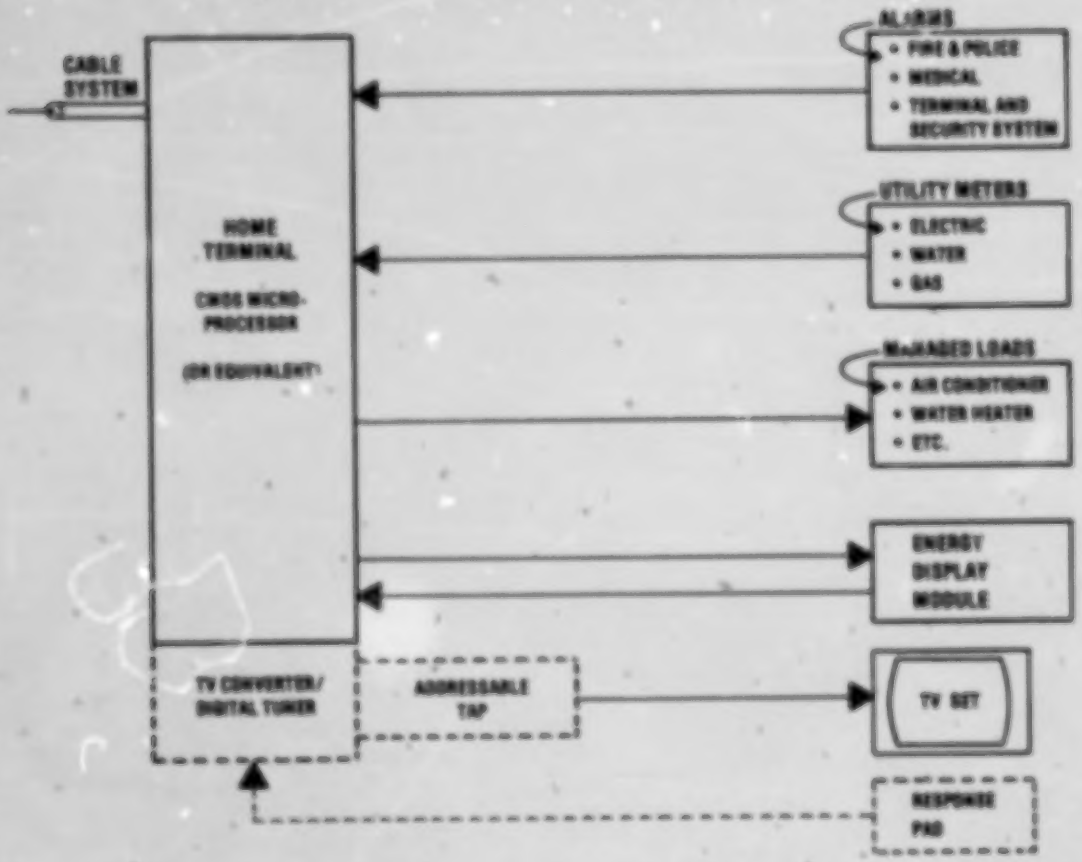


Private sector applications include in-home shopping services such as interactive advertising and a crude form of electronic catalog that would be operating on a fixed schedule. Marketing research applications can be greatly expanded because of the addition of active response. Multiple choice questions can be asked and special video material shown to respondents in their own homes.

The capital cost of the first generation of two-way service is accommodated by the per-program pay TV revenue. The incremental cost of the second generation, e.g., in a more sophisticated terminal and greater computer capacity, may be in the range of $40 to $90 per household or drop. Educational programs (public schools, public safety) which lease the service on a regular basis will cover a portion of that cost. Market research, direct selling and alarm systems should cover the remainder. These are useful applications; however, monitoring in the second generation must be limited to simple closure switches, such as a relay signal from a smoke or heat detector, because only a few data bits are available in the terminal.

Partially because of the limitation of second generation equipment in monitoring applications, the third generation is being developed. The immediate advantage of third generation two-way cable technology is the ability to monitor home activity which requires more complex coding than a single bit.

Figure 2-4. THIRD GENERATION: HOME TERMINAL AND PERIPHERALS



The Third Generation

A necessary part of a residential two-way cable power load management system is the ability to monitor utility meters. While transmitting utility meter information through the upstream communication system represents no technical problem, assuming the 16-bit data format, the scan must be designed to prevent the reading of utility meters from occupying the entire system. The problem for third generation terminal design is to provide 16-bit data words recognizable by the minicomputer as either utility meter information, interactive response or channel status. The terminal itself would be required to alternately select channel status and utility meter information to make possible

simultaneous per-program pay TV and power load management applications.

The only practical solution to the data formatting problem is the addition of a microprocessor chip to the terminal. Microprocessors, such as the RCA 1800 COSMAC series, would add approximately $20 to the cost of the second generation terminal. Adding a ROM chip to store program instructions would allow the microprocessor to accumulate utility meter data and format the 16-bit transmission word at the appropriate times. The third generation terminal is currently being developed. A working diagram is shown in Figure 2-4.

The addition of the microprocessor to the terminal provides flexibility to most second generation applications. The ability to format the 16-bit transmission word within the terminal makes possible the transmission of more complex data from the terminal than simple multiple choice selections. In the in-home shopping application, more complex information such as color, size or credit card numbers could be quickly entered through the keyboard, and then transmitted all at once rather than digit by digit. The marketing research and educational applications would also benefit from the increased input flexibility by being capable of accepting input data more complex than a single digit.

Another improvement in terminal technology is necessary at this step before moving ahead to the fourth generation. To improve control and security of the system, it is desirable to move the essential electronics out of the TV control terminal to a central location on the exterior of the home. This shift, a part of the third generation, does not add anything in terms of potential applications, but rather provides more efficient operation because of increased maintenance convenience and terminal security. The latter is of critical importance, particularly in the utility metering applications and per-program pay television, where thefts of service staggering in magnitude have recently been discovered.

The Fourth Generation and Beyond

The evolutionary steps beyond the third generation are not as clear as the first steps because the associated electronics and information processing technology itself are continually evolving. The next step will no doubt be the addition of low cost memory storage in either the terminal itself, or in a COS. This will make possible the transmission of time-compressed digital signals to a memory in a specific location such as an individual terminal.

The addition of the microprocessor chip to the terminal also makes possible the decoding of downstream information with the addition of a RF receiver to the terminal. While additional signal decoding and character generation circuitry would also be required, it is technically possible to allow selection of portions of downstream data signals using a keying or addressing scheme. If an entire downstream channel were devoted to digital information, then it would be possible to "page" a portion of that data stream for local display on the home television set. This makes possible electronic automated newspapers which the subscriber can page through on demand. One video channel could easily accommodate the equivalent of 1,000 pages. The news could be computer refreshed and controlled. Another application is the delivery of second class mail and on-demand catalogs. A limitation is the probable restriction to digital information. The information is always stored in the downstream communications channel which, given the limited available bandwidth, may not be the most efficient use of the spectrum.

The addition of memory partially solves the problem of inefficient use of available spectrum space, since the electronic newspaper or mail would not always be present in the system, but rather multiplexed on a downstream channel carrying similar signals to other terminals. Not only does this provide for better spectrum use, but it also allows the transportation of more personalized messages.

For this generation of two-way cable terminal to become feasible, the cost of memory will have to drop substantially, a result which can be expected from improved memory technology such as the development of the "bubble memory." This generation also implies substantial increases in the amount of computer power necessary to run the system. With each new generation, the size, speed and computational power of the controlling minicomputer system must be upgraded. Existing minicomputer systems are adequate through the third generation, with the addition of more processing units as the number of terminals in a cable system grows. The fourth generation implies exponential growth in the volume of information which requires processing. It is difficult to speculate beyond this generation because of the rpaid development of associated technology, and it is even possible that the fundamental transmission system will itself change to a lightwave rather than a radio frequency system. It is clear that, in any case, the technology and the associated new applications will continue to grow in a series of sequential evolutionary steps.

Chapter 3

Firefighter Training and the Two-Way Lesson Format

Standardized training, with an interactive component, came up frequently in our investigation of the potential applications of two-way cable. The need for training and retraining in government and the social services is great, in some instances because of the high turnover of personnel and in other cases because of the complexity of tasks and changing technologies. In most situations, cost factors, work schedules and other administrative considerations suggested prepackaged instruction.

In firefighting, daily training is a routine. The National Commission on Fire Protection and Control charges that the fire service is not getting the best equipment and training because the scientific community has not contributed sufficiently. The Commission urges:

> "...the Federal research agencies, such as the National Science Foundation and the National Bureau of Standards, to sponsor research appropriate to their respective missions within the areas of productivity of fire departments, causes of firefighter injuries, effectiveness of fire prevention efforts, and the skills required to perform various fire department functions." (1)

The Commission concludes that "training can favorably influence a department's effectiveness—in saving lives, reducing property losses and preventing injuries to firefighters." (2)

Two-way cable television can bring live or packaged training programs by well-prepared specialists to the firefighter in his station house and provide an opportunity for response and reinforcement. For volunteer firefighters, the training can take place in the home at convenient times.

In Rockford, advanced training is carried out in two ways: (1) in station houses with instruction by self-teaching materials and company officers and (2) at the Training Academy which is specially equipped with training laboratories and materials. Training at the Academy risks underprotection in the district when trainees are removed from their stations, or adds the cost of overtime pay. The Academy could become a center for specialized training and drills and a production center for materials to be distributed to stations by television and other means.

Much of the training takes place on the job as the firefighter moves up in responsibility, as new knowledge is developed and new equipment is acquired. Training Officers in the fire service have one of the more complex training tasks in industry or government. Firefighters generally work 24-hour shifts. Activities are always broken up by fire and emergency calls. Special off-duty days, vacations and sick days complicate the training and record keeping activities. Training by company officers in the station house is dependent on the confidence, ability, training and administrative capability of the company officer. Standardization is difficult to achieve.

Pre-packaged videotape with two-way interaction and reporting could standardize the training, focus attention on the training materials because of the necessity to continuously respond and provide the training officer with an instant record of who participated in the training exercises and who needed to be rescheduled for make-ups. New materials could be created for two-way training or existing training materials could easily be adapted to two-way instruction.

Training Topic

The selection of a topic for the firefighter training experiments was based on the following criteria: (1) overall national importance in the development of fire protection capability; (2) significance of the topic in Rockford; (3) breadth of the learning tasks encompassed; (4) the need for an advanced training area which would be appropriate for almost all firefighters regardless of level of experience.

Prefire planning was selected as the topic for the experimental instruction. Prefire planning is an activity designed to provide the firefighter with a logical and systematic plan for identifying and classifying potential fire problems. This allows the firefighter to carefully formulate, in advance, a tactical or action plan for a given building, in the event a fire occurs. The plans may then be continuously studied in training sessions and taken to a fire should one occur. The goal is efficient containment and suppression with minimum life hazard. The task of prefire planning is a complex process which draws upon the firefighter's previous training and

1. This chapter was written principally by Thomas Baldwin and John Pavlish.

experience. It represents a task facing all fire departments.

In October 1974, a statewide survey of 638 Illinois fire officers revealed that "emergency planning (prefire planning, disaster planning and master emergency planning)" ranked as the number one category of needed subject matter expertise. (3)

Interactive Training

It would be incorrect to suggest that an interactive form of training was dictated by the circumstances of firefighter training in Rockford, since we embarked on the study with the principal objective of employing two-way communication. Nonetheless, the firefighter training application seemed to optimize the potential benefits of two-way training from a central location to remote locations.

In creating the interactive system, we made a number of assumptions about the value of the interaction. These assumptions dealt with specific learning and administrative components, as follow:

Attention and participation. Interactive items, spaced throughout the instructional programs, would force participation and help to keep the trainees alert and attentive.

Motivation. Awareness that each response would be fed back individually and in aggregate scores at the end of the lessons, and that hard copy records would be made, would serve to keep trainees motivated to create a good record.

Feedback. Reinforcement would be provided by the feedback at each step of the instruction.

Competition. Since station or individual scores could be compared, competition would maintain interest and motivation.

Teasing. On occasion, interactive items could be used as teasers to lead into a new segment of instruction. Firefighters would have to guess or rely on previous experience. This technique would heighten interest in learning the material.

Pacing. The interactive questions would serve to break up the television lecture-demonstration format and revive interest.

Drill. Frequent repetition of prefire planning symbols and other material would aid recall. Quizzes would provide a summary and review.

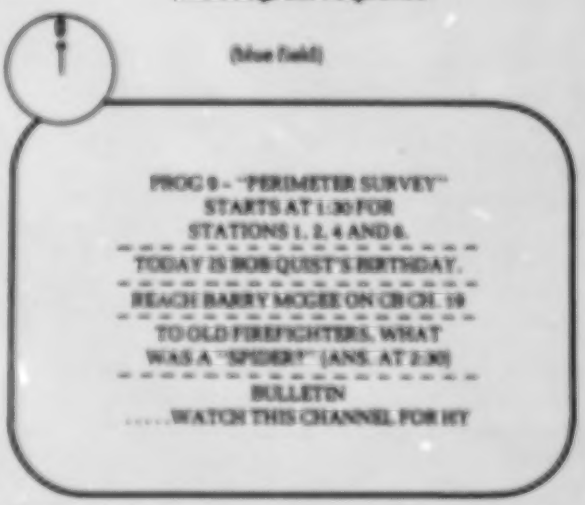
Administration. The interactive system, including a log-in procedure, frequent interactive questions and computer printout of results, would improve training system administration and reduce administrative costs.

The Two-Way Lesson Format

With these hopes for two-way training, keeping within the technology which we had available, the format described here was devised and used throughout the television series.

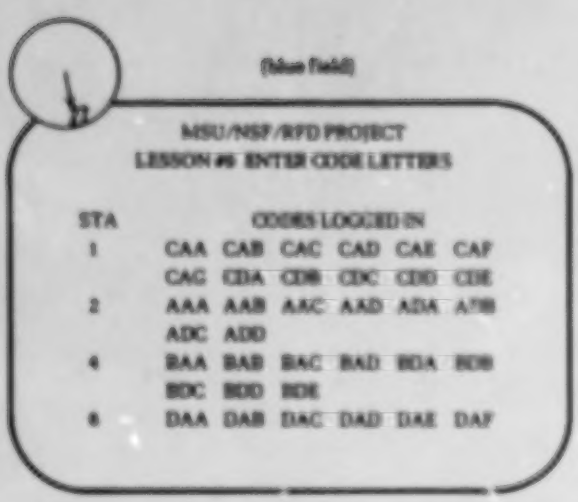
One-half hour before each lesson a pre-program sequence of character generated displays began. These are illustrated below:

Pre-Program Sequence


(blue field)
PROG 0 - "PERIMETER SURVEY"
STARTS AT 1:30 FOR
STATIONS 1, 2, 4 AND 6.
TODAY IS BOB QUIST'S BIRTHDAY.
REACH BARRY MCGEE ON CB CH. 19
TO OLD FIREFIGHTERS, WHAT
WAS A "SPIDER?" (ANS. AT 2:30)
BULLETIN
.....WATCH THIS CHANNEL FOR HY

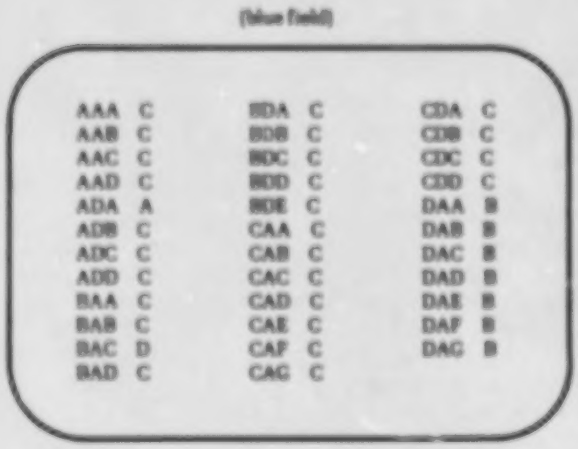
Display #1: The normal character generated display for a day on which a lesson was scheduled consisted of an announcement of the next program time. Added to this were more personalized items dealing with the audience members. Birthdays of firefighters were announced along with information phoned in by the audience. Occasionally, quiz questions were asked dealing with firefighter history, sports, trivia, etc. It was also possible to utilize the bottom line of the display for a longer message which would "crawl" across the screen from right to left.

Display #2: Twenty-two minutes later, a countdown tape informed the men that only five minutes remained before they would be required to log-in. The time at the bottom changed every 30 seconds to keep the audience updated. Music was played under the countdown. The slides over which the message was placed consisted of Rockford scenes and firefighting equipment.


(blue field)
MSU/NSF/RFD PROJECT
LESSON #0 ENTER CODE LETTERS
STA CODES LOGGED IN
1 CAA CAB CAC CAD CAE CAF
CAG CBA CBB CBC CBD CBE
2 AAA AAB AAC AAD ADA ADB
ADC ADD
4 BAA BAB BAC BAD BDA BDB
BDC BDD BDE
6 DAA DAB DAC DAD DAE DAF

Display #3: Five minutes later, the log-in started. The log-in, in effect, registered the participants for the lesson. The firefighters were given five minutes to enter their code letters into the two-way system. As an additional signal to begin the lesson, the words "ENTER CODE LETTERS" were flashed during the entire log-in. The maximum number in the audience for any lesson was 35, distributed as in the above example. As soon as the code was received, it was displayed on the television screen. The time given was ample for all stations to log-in. This time could be reduced to two or three minutes in future training.

ed by depressing A, B, C, D, or F (can't decide) on the terminal and then the transmit button. As soon as a response was received for all codes logged in, the responses of each, by code, appeared on the television screens.



Feedback #1: This type of feedback gave the audience the answer selected by each individual as identified by the code letters. This was used for the majority of the interactive items.

Display #4: After the log-in, the lesson announcement was displayed for approximately 15 seconds before the video tape started.

Feedback #2: This type of feedback gave the number selecting each option. It was used only occasionally to vary the feedback.

During the lesson, a question was asked for each major instructional point made, within every two to five minutes. These were usually visual questions with four answer options. The firefighters respond-

The feedback confirmed receipt of the answers and gave a view of how all others answered. If not all answers had been received in 30 seconds, those responses received to that point were printed. If an

individual, or group, failed to respond to two consecutive questions, they were dropped and the computer thereafter read only the remaining codes for purposes of advancing the lesson. This was necessary because stations were sometimes called to a fire during a lesson.

After the display of answers, the system automatically returned to videotape and the narrator discussed the correct answer. The questions had been designed so that they represented small learning steps as in programmed instruction. The programs were designed to have a correct response rate of about 90 percent so that the learners would have consistent positive reinforcement. Over all the lessons, the average was 89.61 percent, with very few questions falling below the 80 percent level.

Occasionally, "challenge questions" were asked. These did not relate to information previously covered, but led into instructional material to follow. The object was to stimulate interest, teasing the learners into the next unit.

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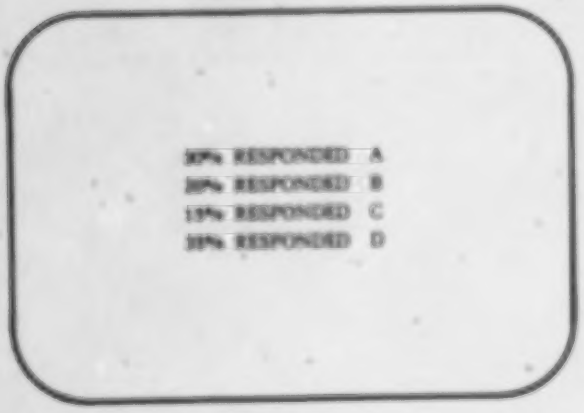


Feedback #3: Feedback like this was used for "challenge questions" which asked the firefighters to give opinions about information that had not yet been presented. It displayed the percentage selecting each option.

At the end of each lesson, a "quick quiz" reviewed the material presented in that lesson and prior lessons, particularly the prefire planning symbols. These questions were not paced by the participants, as were the interactive questions described above, but had a fixed five-second period for answering. After the quick quiz, the percent correct for each participant was printed on the screen.

(blue field)

QUIZ PERCENTAGE

AAA	100	BDA	100	CDA	80
AAB	100	BDB	100	CDB	80
AAC	80	BDC	90	CDC	80
AAD	100	BDD	100	CDD	80
ADA	100	BDE	100	DAA	100
ADB	90	CAA	80	DAB	100
ADC	100	CAB	80	DAC	100
ADD	100	CAC	80	DAD	100
BAA	70	CAD	80	DAE	100
BAB	100	CAE	80	DAF	100
BAC	100	CAF	80	DAG	100
BAD	100	CAG	80		

Feedback #4: After "quick quizzes," the character generator displayed the percentage correct for each individual.

After the quick quiz feedback was presented, the narrator reviewed the correct answers.

The lesson concluded with a character generated presentation of the percent correct over the whole lesson, combining the quick quiz with all other questions.

(blue field)

LESSON PERCENTAGE

AAA	100	BDA	100	CDA	80
AAB	100	BDB	90	CDB	80
AAC	75	BDC	90	CDC	80
AAD	98	BDD	100	CDD	80
ADA	100	BDE	100	DAA	95
ADB	80	CAA	80	DAB	95
ADC	100	CAB	80	DAC	95
ADD	90	CAC	80	DAD	95
BAA	65	CAD	80	DAE	95
BAB	100	CAE	80	DAF	95
BAC	95	CAF	80	DAG	95
BAD	100	CAG	80		

Feedback #5: At the end of each lesson, a total score was given which reflected the percentage correct for each individual over all of the interactive items and the quick quiz.

Participants also saw the percent correct for each shift of firefighters over all lessons to date. The last two types of feedback introduced an element of competition. After the lesson was concluded, a few minutes of relaxation for the firefighters was provided by interactive computer games.

(Blue Field)

SHIFT AVERAGES TO DATE

AAA	95	BDA	91	CDA	93
AAB	93	BDB	88	CDB	93
AAC	91	BDC	87	CDC	93
AAD	92	BDD	100	CDD	93
ADA	100	BDE	78	DAA	88
ADB	89	CAA	91	DAB	88
ADC	94	CAB	91	DAC	88
ADD	90	CAC	91	DAD	88
BAA	79	CAD	91	DAE	95
BAB	100	CAE	91	DAF	88
BAC	93	CAF	91	DAG	88
BAD	95	CAG	91		

Feedback #5: The final feedback for each lesson was a display of the average score of each individual to that point in the series.

Immediately after each lesson, complete written reports on the lesson performance for each participant were produced on the line printer. This included an item-by-item response of each individual, by code letters, and the individual's final lesson score. Across the bottom of the report was the percentage correct for each item. This was followed by the scores on each lesson of the series to date for each individual and the average score for the series. This report, which was blank for each incomplete or missed lesson, was used to schedule make-ups

Computer Functions

A special user-oriented computer language was developed for setting up the lessons in the computer. The parameters of each lesson were determined and stored—the types of questions, text of character generated messages, color backgrounds, nature of feedback, correct answers, etc. The times that specific operations were to be performed were also stored in the computer. During the lesson runs, the separately entered operations and timecodes on the videotapes were automatically coordinated by the lesson processor program, which controlled the entire administration of a lesson.

These operations include starting and pausing the videotape, switching to character generator, scanning the terminals for responses, generating feedback, restarting the videotape, aggregating scores and making printed reports. Once a lesson began, everything from the log-in through the final summary report was automatic.

The computer functions are described in detail in Chapter 5. Computer program documentation is in a separate volume. (4)

Notes — Chapter 3

(1) National Commission on Fire Prevention and Control, *America Burning*, (Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1973), p. 187.

(2) Ibid., p. 37.

(3) John F. Cregan, "What Management Courses Do Fire Chiefs Need?" *Fire Chief Magazine*, April 1975, pp. 41-45.

(4) Martin F. Block, John B. Salemberg, Eric S. Smith and Jayne W. Zanaty, *Michigan State University-Rockford Two-Way Cable Project: Minicomputer System Software*, Volume III, Final Report, NSF Grant No. APR 75-14288, June 1978.

Chapter 4

Lesson Development Cycle: Content Research Through Production and Formative Evaluation[1]

This chapter describes the development of the 12-lesson prefire planning series, from content organization, pretesting and scripting through location and studio production and formative evaluation.

Organization of Prefire Planning Content

Having decided on prefire planning as the topic for two-way instruction, the potential course content was analyzed. The project Field Director accompanied Rockford Fire Department officers on prefire plan surveys of two buildings and observed the follow-up process. From this experience the flow chart, shown in Figure 4-1, was prepared.

The two buildings surveyed were a high rise apartment for the aged and an industrial complex which presented specialized hazards to firefighters and perimeter buildings. Task analyses were performed on the prefire plan survey process for each building. The survey function was of major importance for the instruction, since surveying was to become the responsibility of the firefighters and their company officers.

Once the building survey was completed, several steps were taken to convert the raw survey information and diagrams into finished prefire plans, with separate formats for fire commanders and fire companies. The task analyses for the two building types and the post survey steps appear in Appendix IV-1.

To avoid confusion on terms and documents in prefire planning, certain terms were defined and described.

Prefire Planning Terminology

Prefire Plan Survey—The form used by firefighters when initially surveying a building for which a prefire plan is being developed. The survey is designed to contain all of the pertinent information necessary to make a successful prefire plan. From the survey, diagrams will be drawn which represent the building and an initial reaction plan will be formulated. At the company level, pertinent information will be extracted by individual engine and ladder units. The prefire plan survey itself will then go on file for use by the company officers. At the district level, a completed prefire plan survey will be kept in the Chief's file.

Floor Plan Diagrams — Graphic representations of the floors of the selected building for which a prefire plan is being developed. The diagrams will include all utility shutoff locations, F.D. connections, important internal structures and any other structures that would affect firefighting operations. There will be diagrams for every important floor and for all areas that present particular hazards.

Perimeter Diagram — Graphic representation of the area surrounding the selected building for which a prefire plan is being developed. The diagram will include all shutoffs, hydrants, exposures, F.D. connections and important structures.

Initial Reaction Plan — Plan developed by district chiefs with input from company officers which verbally tells which F.D. vehicles are to be positioned in the initial response to a fire in a selected building.

Prefire Plan Packet — Packet containing the prefire plan survey, floor plan diagrams, perimeter diagrams and the initial reaction plan which is sent to the individual fire companies so that pertinent company information can be extracted.

Pertinent Information Extract — List of important company information obtained from the prefire plan survey. This extract will be individualized for each company based upon its role in the initial reaction plan.

Prefire Plan — The compiled information packet at the company level which will be used by firefighters in individual companies. This packet contains the floor and perimeter diagrams, the initial reaction plan and the pertinent information extract. (It is important to note that for the district chiefs, the "Prefire Plan Packet" serves the function of the company's "Prefire Plans." District chiefs will carry the entire packet to a fire while the individual companies will carry their personalized documentation.)

Programs

With the task analyses in hand, an attempt was made to reorganize the fire department's prefire plan survey form into areas that could be treated se-

1. This chapter was written principally by John Pachuta, Bradley Greenberg, Micky Draganoff, Thomas Baldwin and Michael Sheridan.

Figure 4-1. FLOW CHART FOR PREFIRE SURVEY AND PLANNING

START
CONTACT OWNER/MANAGER TO ARRANGE FOR APPOINTMENT
EXPLAIN PURPOSE OF PREFIRE PLAN AS OPPOSED TO FIRE INSPECTION
ARRANGE FOR TIME TO DO PREFIRE PLAN SURVEY
CONDUCT PREFIRE PLAN SURVEY IN BUILDING
CONDUCT PERIMETER INSPECTION
RETURN TO STATION TO ANALYZE DATA
IS ALL INFORMATION ON PREFIRE PLAN SURVEY FORM COMPLETE?
NO
YES
RETURN TO BUILDING TO COMPLETE SURVEY INFORMATION
IS IT NECESSARY TO COLLECT SUPPLEMENTAL INFORMATION?
YES
NO
RETURN TO BUILDING TO COLLECT SUPPLEMENTAL INFORMATION
IS IT NECESSARY TO PHYSICALLY POSITION VEHICLES AT BUILDING?
YES
NO
RETURN TO BUILDING AND PHYSICALLY POSITION VEHICLES
DIAGRAM ALL PERTINENT FLOORS OF BUILDING
DIAGRAM ALL PERTINENT STRUCTURES IN AREA
PLAN INITIAL RESPONSE AND VEHICLE POSITIONS[1]
SEND PLANNING PACKETS TO INDIVIDUAL COMPANIES[2]
COMPANY OFFICERS EXTRACT INFORMATION PERTINENT TO THEIR INITIAL RESPONSE
PREFIRE PLAN SURVEY FILED FOR USE ONLY BY COMPANY OFFICERS
DIAGRAMS, INITIAL RESPONSE AND PERTINENT COMPANY INFO ON FILE AS COMPANY PREFIRE PLAN
END

1. Done by high-ranking fire department officers with input from salaried personnel.

2. Packet has prefire plan survey, diagrams and initial response.

quentially in the lessons. The form was revised to accommodate this need. The broad content areas of the form, and the items included within each area, were the basis for several of the lessons. The format of the survey was adapted to the graphic demands of television to achieve isomorphism between instruction and practice. A copy of the survey and revision forms appear in Appendix IV-2.

The Rockford Fire Department preplanning process was broken down into a proposed series of 14 lessons. The original breakdown underwent several transformations as the subject matter was fully researched and scripts timed. The result was a 12-program instructional series which is described below.

Program #1—Pretest: This tape combines 27 interactive items from the eight tapes that follow into a pretest to determine entry-level knowledge. At least two behavioral objectives from each of programs #2 through #9 are tested in this tape. The scores can be used as a basis of comparison with the later posttest (program #10) to measure learning.

Program #2—Introduction to Prefire Planning and Fire Protection Equipment, Part 1: This lesson introduces the learner to the concept of prefire planning and briefly looks at each of the steps in the prefire planning. The building survey report form is introduced. The videotape simulates various survey situations before giving examples of form entries. This practice of giving sample form entries is carried through the tapes that follow until the entire form is completed in program #5. The learner is introduced to the topic "Fire Protection Equipment" with a discussion of various types of automatic sprinkler systems. The use and characteristics of wet, dry and deluge systems is discussed. The videotape also looks at automatic chemical sprinkler systems and briefly introduces the major types found in buildings. The use of prefire planning symbols in formulating final diagrams is presented. The symbols for various sprinkler systems and sprinkler controls are introduced.

Program #3—Fire Protection Equipment, Part 2: This program continues the discussion of fire protection equipment by introducing learner to the prefire planning survey of fire pumps, alarm systems and various structures found in the yards of buildings. Again, examples of real situations are given and the learner is shown how to record the information for later reference. Eight additional prefire planning symbols are introduced and the learner responds to a drill on these symbols and symbols learned in the previous lesson.

Program #4—Building Construction, Part 1: Introduction to the important points in surveying building construction; in this part, types of roof construction and structures found on roofs. Prefire planning symbols for roof structures are introduced. The learner is shown how to diagram a roof and its contours. Drill on symbols learned so far.

Program #5—Building Construction, Part 2: Additional aspects of building construction are introduced; particularly, various types of door and window construction. A brief presentation of utility shutoffs gives the learner information on the important shutoffs and how they should be listed on the survey form. Prefire planning symbols for certain doors and shutoffs are presented and several tactical considerations concerning forcible entry and ventilation are discussed. Symbol drill.

Program #6—Vertical Structures: This program concentrates on vertical movement during a fire by discussing stairways, smoke-proof towers and elevators. The learner is given an extensive look at "emergency service" elevator operation and an overview of the components which make up overall elevator construction. Five more prefire planning symbols are introduced. Symbol drill.

Program #7—Communications, Rescue and Salvage: The survey items specific to communications, rescue and salvage at the fire scene are identified. Such unique situations as preparation for the rescue of handicapped and bedridden people and the significance of pressurized structures are described. There are no new symbols presented in this lesson, but the quick quiz at the end of the program checks symbols from previous sessions.

Program #8—Hazardous Materials: This program looks at the properties of hazardous materials and explains what actions should be taken with unknown substances while on a prefire plan survey. Information from the *Fire Protection Guide on Hazardous Materials* is stressed. The learner is given examples of entries from the five codes in the *Guide*. The symbol which will be used to mark a hazardous area is presented. Symbol drill.

Program #9—Perimeter Survey: This lesson takes the learner outside of the building being surveyed and incorporates information about structures and obstacles found on the perimeter of a building. A perimeter diagram is developed and rules are established about making a rough sketch of the area surrounding a building. No new symbols are introduced in this lesson, but a quiz checks a sampling of symbols from previous lessons.

Program #10—Posttest: This program tests the learner on information presented in the previous eight lessons. The 76 questions in the posttest incorporate 27 that were asked in the pretest (program #1), plus 22 more that were asked in the programs. The 27 questions remaining were based on the content of the tapes but had never been asked of the learners.

Program #11—Post-Survey Steps: This lesson discusses the actions that take place after a building survey report has been completed by the prefire planning team. Emphasis is placed on administrative procedures associated with the prefire planning process and upon the role of each person in the overall system.

Program #12 — Survey/Plan/Utilization: This lesson rounds out the prefire planning course by acting as both a test and a good example of how to prefire plan a building. Roper-Whitney, Inc., of Rockford, Illinois, is preplanned. The learner is taken from the initial contact with the building owner, through all the steps. The questions asked in the tape require that the learner recall information from previous lessons. The lesson is a second posttest, verifying the learning of discrete items of information as well as the student's ability to synthesize the elements of the process.

The behavioral objectives for all of these lessons appear in Appendix VIII-3, Posttest and Behavioral Objectives.

Pretesting Through Scripting

The following sections describe the prefire planning program development process from its beginning state to its completion as a series of videotaped lessons. Each step is discussed in chronological order. A quick overview of these steps is given in Figure 4-2, which is a sample of the progress chart used during the project production.

Program Series Outline

From a task analysis of the prefire planning process, an outline of program topics was prepared. The outline of topics underwent several revisions as research into the content progressed and as the length of each topic became apparent. To simplify the description of the development cycle, a single program has been selected. It is Program #9 in the series of 12 programs, titled "Perimeter Survey."[1] The portion of the prefire planning survey form on the building perimeter is Appendix IV-3.

Initial Research

Initial research for each topic was conducted by a project research assistant in conjunction with the Field Director. The researcher was a member of the Rockford Fire Department. He listed all areas under a particular topic which should be considered and pretested prior to inclusion in the script.

Behavioral Objectives—First Drafts

After discussion with the research assistant, the Field Director formulated a first draft of the behavioral objectives for the videotape. These objectives attempted to include all material which should be pretested and evaluated later. One of the preliminary objectives for the perimeter survey lesson was: "The learner will identify specific items on the perimeter of a selected building (a) exposures, (b) overhead obstructions, (c) ground obstructions, (d) adjoining structures and (e) combustible materials." Appendix IV-4 is the first draft of the complete set of behavioral objectives for the topic "Perimeter Survey."

1. In the Appendices for this Chapter, the program is occasionally referred to by the number "9" which was assigned earlier to the lesson.

Figure 4-2. ROCKFORD TWO-WAY CABLE PROJECT
PREFIRE PLANNING INSTRUCTIONAL PROGRAM DEVELOPMENT PROGRESS
THROUGH OCTOBER 1, 1976

Program	Task: Preliminary research and outline	Review and objectives	Pretest written	Review of pretest & objectives	Review pretest	Administer pretest & interview	Review of pretest report	First draft of script	Script revision	Script revision	Final script review	Location shoots	Graphics	Production	Pre-audition production	Narration	Final review
1. Pretest	XX	XX	—	—	—	—	—	XX									
2. Introduction and Fire Protection Equipment	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX			
3. Fire Protection Equipment, #2	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
4. Building Construction, #1	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
5. Building Construction, #2	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
6. Vertical Structures	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX			
7. Communication Rescue & Salvage	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX				
8. Hazardous Materials	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX						
9. Perimeter Survey	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX					
10. Posttest	XX	XX	—	—	—	—	—	XX									
11. Post-Survey Steps	XX	XX	—	—	—	—	—	XX	XX								
12. Survey/Plan/Utilization	XX	XX	—	—	—	—	—	XX									

Rockford Fire Academy Review

The behavioral objectives were then discussed with personnel at the Rockford Fire Academy to assure that the topics and issues listed were indeed vital to the individual firefighter. The Field Director weighed these comments and, as necessary, modified the behavioral objectives based upon comments received at the Academy.

Since much of the prefire planning process concentrates on the new application of existing skills rather than the learning of altogether new skills, the entry level knowledge of the Rockford firefighters had to be determined. Therefore, at least three individual questions were drawn up for each objective and sub-objective. The items were coded by objective to facilitate scoring and cross-referencing. A few affective items, which remained the same for each pretest, were added to get an impression of the value placed on the content and its level of difficulty.

First Michigan State University Review

The draft of the pretest along with the behavioral objectives was then sent to Michigan State University, where the on-campus research staff reviewed the work. This review was an opportunity for "third parties," not part of the initial research but knowledgeable in instructional design and research methods, to look at the material from a new perspective. Comments were returned to the Field Director for incorporation in the next behavioral objective and pretest revision. Appendix IV-5 contains comments received from the on-campus researchers on the first drafts of material on "Perimeter Survey."

Behavioral Objectives — First Revision

The Field Director then incorporated all comments into the pretest experience. Appendix IV-6 shows the revised objectives based upon the comments from Michigan State University in Appendix IV-5. Appendix IV-7 is the revised pretest, reflecting the new behavioral objectives. For example, subheading A. "exposures," under objective #1, is tested by questions #3, #20 and #26. All of these questions are coded "1A" in the left-hand margin of the pretest.

Pretest Administered

The pretest was then administered to firefighters in Rockford Fire Station Number Seven, which is located outside of the cable system coverage. The men assigned to that station perform the same tasks and undergo the same training as men from other fire stations in the city. Because they are beyond reach of cable and could not participate in the experimental program via cable, the firefighters at Station Number Seven participated as subjects for pretesting and formative evaluation. A total of 15 men are assigned to the three shifts at that station.

Analysis of Pretest Results

The Field Director scored the pretest and analyzed the responses given by the men. Appendix IV-8 is the analysis of the pretest results for "Perimeter Survey." Scores are listed for each individual firefighter and a score for each objective and subobjective is tabulated.

A system was initiated to determine which objectives should receive priority in the development of interactive items. Any objective for which the questions received scores lower than 75 percent were included in the content of the tape and were the subject of an interactive item. The percentage figures served as guidelines and were altered depending upon test results and content area. The content of questions scoring poorly in the retest was singled out for emphasis in the program script. Affective item results were also compiled and compared to similar items from previous pretests.

Behavioral Objectives — Second Revision

The Field Director again revised the behavioral objectives based upon the pretest analysis. Appendix IV-9 is the second revision of the behavioral objectives for "Perimeter Survey." Based on the pretest, objective #1 was revised into a more compact format.

Second Michigan State University Review

The pretest results and the revised behavioral objectives were then reviewed at Michigan State University. Any discrepancies in the analysis were noted and, if appropriate, a third revision of the behavioral objectives was suggested. In the case of the topic "Perimeter Survey," the second revision of the behavioral objectives was not changed.

Script — First Draft

The Field Director then used the revised behavioral objectives and the pretest data to write the first draft of the videotape script. An outline of the material to be covered was formulated, and interactive items were incorporated into the content. Appendix IV-10 is the initial outline for the videotape dealing with "Perimeter Survey." All of the information pretested was then weighted, in accordance with the scheme outlined above, based on the test scores and placed in the outline of material.

Appendix IV-11 is an analysis of the interactive videotape items dealing with "Perimeter Survey." All objectives were covered by interactive items during the videotape experience.

Third Michigan State University Review

The first script draft was then sent to Michigan State University where it was read and reviewed. Objectives were matched with pretest results and the script was edited for content clarity.

Consultant Review

At the same time, the script was also given to content consultants, experienced in the content of the field being discussed. They read the script for accuracy of content.

Script — Second Draft

The Field Director then wrote the second draft of the script based on the comments from Michigan State University and the content consultants.

Fourth Michigan State University Review and Final Script

The second draft of the script was sent to the Michigan State University Project Director who made a final script review. The Field Director finalized the script based on these comments.

Location Production

The basic production for each of the programs was done in Rockford under the following plan:

(1) Each program would present a specific content area. The total series would be 10 to 15 programs.

(2) Each program length would be determined by the content covered but would be scripted to range between 30 and 40 minutes.

(3) Each program would incorporate as many interactive questions as possible. Interaction would occur at least once every five minutes.

(4) Each program in the series would be capable of use as a two-way interactive experience and also as a traditional one-way program. (This would allow use of the series outside the two-way technology for the one-way experimental versions and also in conventional television systems where the two-way technology is not yet available.)

(5) Type faces for graphics would be standardized for visual continuity.

(6) A modular studio set design would be employed to provide an individual look to each program while retaining a series identity.

(7) A rear projection screen would be incorporated as one of the main elements of the studio set to create visual reinforcement as material is presented and to facilitate transitions.

(8) A professional television announcer would be used as the on-camera presentor for convenience of production and communication effectiveness.

(9) Pacing mechanisms would be used in each program to break the delivery of information:

(a) A cartoon character named Godfrey to present historical firefighting vignettes,

(b) musical interludes to provide background for visual review material or to provide comic relief, and

(c) a voice change (female to deliver the questions and multiple choice options at interactive points.

(10) All alphanumeric questions would be displayed with red backgrounds. The computer-generated feedback and the indication of the correct answers would be displayed on blue backgrounds. This would be consistent over the entire series to cue viewers to particular behaviors or expectations.

During development and production, the Field Director acted as content researcher and writer. In preparing scripts, a unique script format was necessary to accommodate the computer and character generated elements of the programs. Instead of the usual television script form with audio and video columns, the two-way television script included a third column at the far right with directions for the computer. Had the computer directions been included in the audio and video columns, they would have interfered with the script reading during video production. A sample script page is presented in Chapter 5, Figure 5-6.

The videotape was produced with five-second "bridges" at the end of the presentation of the options for an interactive question. These were simply an extension of the visual for five seconds without audio. After an interaction and feedback display, it permitted the computer to begin rolling the videotape prior to the point where it would switch the video output from character generator to videotape, avoiding a roll.

During the production of the videotapes, the right hand "computer column" was ignored except to insert the five-second bridges. The column was not used again until the lesson was timecoded and programmed for computer control.

The special script format and the five-second bridges were the only special production arrangements necessary to accommodate the two-way television presentation. (Since the firefighter training series, University of Michigan, Rockford Public Schools and SwedishAmerican Hospital producers have easily adapted to the two-way production.)

After the initial script draft, the Producer attempted to mold the content into a cohesive visual experience. Visualizations and demonstrations were designed to emphasize the specific objectives. The script drafts were also reviewed and revised by the project advisors at the Rockford Fire Department and Michigan State University.

A typical program averaged 40 minutes in length, included 200 slides and a few minutes of motion picture film in addition to studio action. In some cases the studio presentation included models, props and graphic displays. The average production sequence necessary to create all these elements from start to finish for each program was 10 to 12 weeks. After the third program in the series a graphic designer/artist shared the workload with the producer. Because of the number of programs and the time frame, it was necessary to work on two to three programs simultaneously, all in different stages of completion. This required the development of a very elaborate production status board. Below is an example of the basic sequence of production events.

(1) Add production modifications to the final draft of the script

(2) Hold script finalization meeting with writer and production staff

(3) Storyboard script—layout words, number slides, sketch diagrams and describe all photos (See example in Figure 4-3)

(4) Create all checklists for location shooting of slides and film, graphic type specifications, color art graphics, studio models
(5) Prepare and proof typesetting list
(6) Paste-up and proofread type
(7) Revise storyboard pending location shooting of appropriate examples of content
(8) Keyline diagrams and symbols
(9) Create color art (Godfrey and/or diagrams)
(10) Copy and mount photographs
(11) Run through program elements with Fire Department advisors
(12) Revise as necessary from advisors' critique
(13) Complete all production elements
(14) Run through again to check all production and content elements
(15) Revise script pending corrections from run-through
(16) Duplicate and distribute script 20 days before studio production
(17) Type Teleprompter copy
(18) Produce all corrections and revisions slide/film/graphics
(19) Run through a final time of all program elements by staff and advisors
(20) Package program for travel to studio production center

Status boards were designed to track each program through its various stages of development. The scheduling of work and production dates had to be done over an extended period to allow enough time to accomplish all these steps.

All production work was done in a temporary studio constructed next to the Project Field Office at Fire Station Number Two in Rockford. (See Figure 4-4.)

Studio Production

All of the studio and post production was done in the WKAR Television studios at Michigan State University. The performance and credibility of the on-camera presentor had been pretested with firefighters who were not included in the experiment in Rockford by using a television training program he made for the Michigan State Police. He scored very well on all the criteria—credibility, likeability and style. For audio pacing and interest, another distinctive voice was used to narrate the Godfrey historical vignettes and a third voice, female, to narrate all questions and answer options. Natural sound and musical openings, bridges and closings were also used.

Since the Producer arrived at WKAR-TV with essentially a prepackaged program the primary problem was to communicate the program style and detail to the production staff. The WKAR producer/directors were assigned to the prefire planning productions on a rotating basis. The assistant director, however, remained throughout providing continuity to the production functions.

Formative Evaluation and Revision

After production of the videotape based upon the finalized script, formative evaluation took place at Station Number Seven (which was not a test station in the final experiment). Firefighters on all three shifts viewed the videotape, using answer sheets to respond to the interactive items. The Field Director observed as the firefighters viewed the tape and noted any reaction to the content presented or to treatment of material.

After the viewings, the Field Director conducted informal debriefings with the firefighters and listed their comments concerning the program. These sessions lasted approximately half an hour and all firefighters present were asked to contribute to the discussions. (See Appendix IV-12.)

Additionally, the program was viewed by personnel at the Rockford Fire Academy, by project consultants and by on-campus researchers. The Field Director noted comments by the first two. Michigan State University researchers sent their comments to the field office in written form. (Appendix IV-13.)

Finally, input from all sources was combined into a concise list. The comments were reviewed point-by-point by the Project Director and the Field Office. A disposition for each comment was determined four weeks before the scheduled date for final revision in the studio. (Appendix IV-14.)

The Producer then returned to the studio and modified the program into the decided-upon form. If a program was to undergo extensive modification, this required the creation of additional graphics and of new or partially new segments. After modification, the videotape was again viewed by the Fire Academy, project consultants, Michigan State University researchers and the field office. If the revisions met the desired goal, the program was considered complete and usable on the two-way cable television system.

Figure 4-3. STORYBOARD

PROGRAM # 12

ASSIGNED TO:

KARYL ✓ COMPLETED _____

MIKE _____ COMPLETED _____

FRAME

c) EXPLAIN THE DIFFERENCE BETWEEN FIRE INSPECTION AND PREFIRE PLAN SURVEY

AUDIO 68.6

DESCRIPTION

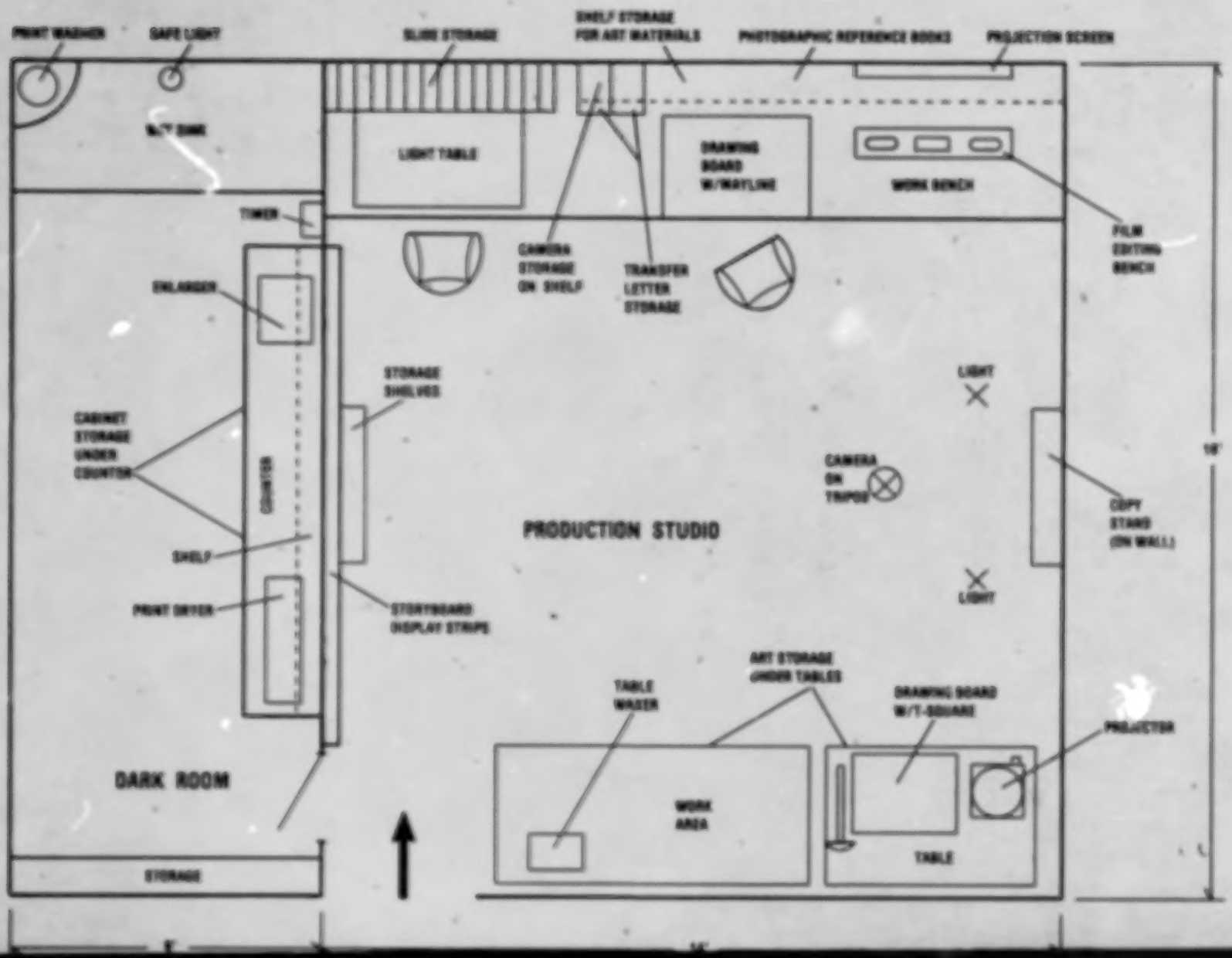
SUPER SLIDE ✓

SELLED _____

COLOR SLIDE _____

B.P. SLIDE _____

Figure 4-4. PRODUCTION STUDIO FIRE HOUSE NUMBER TWO, ROCKFORD, ILLINOIS



Chapter 5

Minicomputer Hardware and Software Design[1]

The introduction of two-way cable communication technology permits the development of a new instructional system which combines the advantages of television and computer-aided instruction for potentially large populations at relatively low cost. The design of the minicomputer-based two-way cable instructional system began with three basic objectives: (1) to deliver instructional lessons via a two-way cable television system using a push-button response pad to transmit student interactions; (2) to place all phases of lesson administration under minicomputer control, providing a completely automated lesson processor system). (This included integration of videotaped material with character-generated displays, polling of student interaction and maintenance of student records.) and (3) to develop a system that could be easily adapted to any subject with system instructions that could be understood by noncomputer personnel.

The entire instructional system represents a combination of complex hardware and software. The hardware necessary to support instructional programs of this kind begins with a viable two-way cable television system, to which is added minicomputer-controlled video origination equipment. The software must coordinate the processing of a series of lessons, including control of all necessary video equipment and monitoring of student interactive responses, in real time. The hardware and software configurations for the Rockford experiments were designed to accommodate the simultaneous administration of two different lessons over separate video channels.[2]

System Overview

The Michigan State University/Rockford digital-return, two-way cable communication system in the firefighter training experiment uses response pads designed by Coaxial Scientific Corporation at a small-quantity cost of $150 each. These terminals are much lower in cost than the $300 terminals used in most other systems. They are modified standard cable television channel converters (Jerrold SX-2). Each standard converter has 12 push-button switches and a three-position band switch, normally used for selecting up to 36 cable channels. The adapted converter has, in addition, a four-position response mode switch, a response transmit button and a response indicator light. The response mode switch can be set to the normal channel selection mode, or to one of three designated response channels. (Figure 5-1.)

Figure 5-1. Response terminal. Modified Jerrold SX-2 channel converter.

When a response channel is selected, the 12 push-button switches and band switch function as an alphanumeric keyboard, whose symbols may be arbitrarily assigned, (e.g., a template may be placed over the keyboard to provide specific operation instructions). The terminal's transmitter continuously sends a 16-bit data word to the computer-controlled receiver located at the headend. This data word reports the status of the keyboard and function switches, as well as other pertinent information. When a user wishes to transmit an upstream response, he or she depresses the corresponding push-button switch and then depresses

1. This chapter was written principally by Martin Block, Jayne Dewey, John Eulenberg, Michael Corbett and Eric Smith.

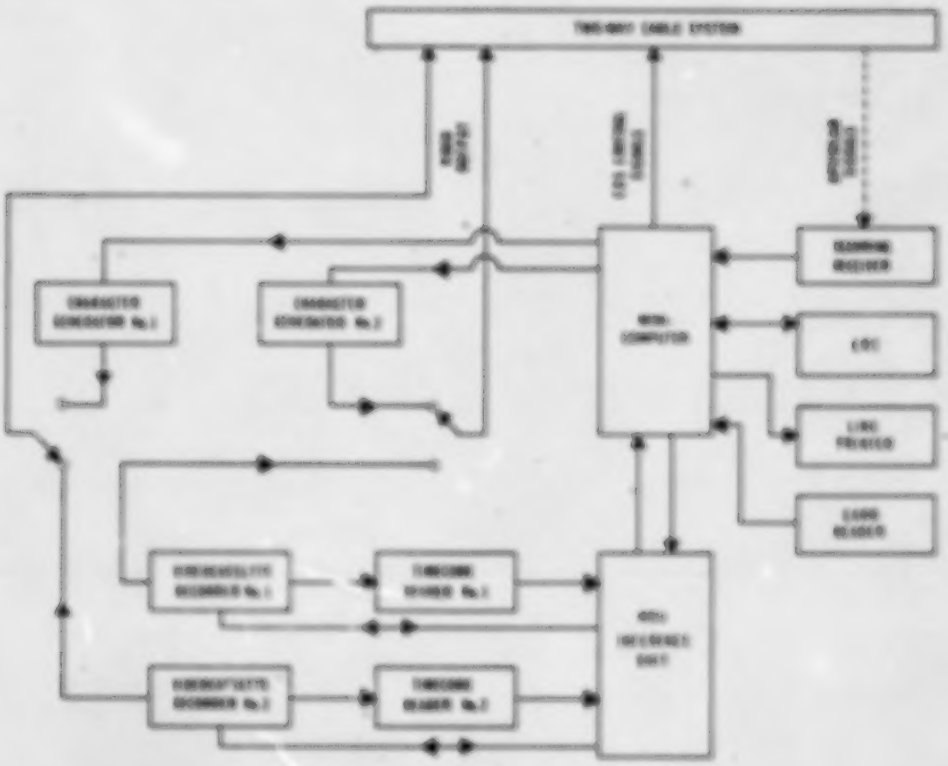
2. During the actual firefighter experiment, however, only one lesson was run at a time.

the response transmit button. This sets a response bit in the data word for a short time, during which the response indicator light is illuminated.

In order to accommodate a large number of terminals, the cable network is accessed by the technique known as area multiplexing described briefly in Chapter 2. In this technique, the network is divided into a number of primary sectors, each further divided into secondary sectors. The upstream signal from each primary and secondary sector is passed by digitally controlled in-line code-operated switches (COSs). At any one time, the computer can scan a secondary sector of up to 200 terminals, addressed by selecting a combination of one primary and one secondary switch. Each terminal within a secondary sector has its own unique frequency. The computer-controlled receiver tunes in on this frequency in order to read the data word from the terminal.

The minicomputer which controls the system is a General Automation SPC-16/65 with 64K 16-bit word memory; real time operating system; 10 megaword disk storage; and necessary peripheral equipment, controllers and interfaces. This is shown in Figure 5-2 in diagram and photograph. An essential component in the headend hardware configuration is a timecode generator/reader, used to synchronize videotaped lessons with their corresponding computer interactions. The Michigan State University/Rockford system's Shintron 387 timecode unit communicates with the computer via a video interface module designed and built for the project at Michigan State University's Artificial Language Laboratory. For computer-generated text, the system uses a character generator which provides four different software-selectable color backgrounds. The computer also controls a video switch which selects either the video-cassette recorder/player (VCR) or the character generator as the source of the out-going video signal. Terminal data is collected using a transmitter and scanning receiver designed by Coaxial Scientific Corporation.

Figure 5-2. SYSTEM CONFIGURATION



Minicomputer System

The minicomputer system consists of the minicomputer and various peripheral devices and controllers as shown in Figure 5-3. The General Automation SPC-16/65 is configured using the General Automation RTOS II real time disk based operating system.

The minicomputer itself, designed as a general purpose machine, has 65,536 words of 16-bit core memory and a 960 ns memory cycle time. The minicomputer features the extended processor option which adds hardware multiply and divide, and foreground and background processor capability; and the real time failsafe group which provides a real time clock operation, monitor alarm, system safe line and power fail restart interrupts. Also included in the RTOS II package is a disk storage capacity of 5.0 million words (16 bits) with an average access time of 80 ms. The disk storage drives consist of two units with one fixed and one removable pack on each unit. Data on the disks is formatted 400 words per sector with eight sectors per track.

The control device for the system is a Hazeltine 2000 CRT terminal connected to the system using a 9600 baud line. The ASR-33 Teletype unit is used primarily for system maintenance but can also be used as a backup system control device.

The 400 card per minute card reader reads standard 80-column cards and is used to configure the system, input programs and update and maintain application disk files. The 200 line per minute line printer uses standard ASCII code and prints up to 132 columns of five-by-seven dot matrix character style with six or eight lines per inch spacing. The line printer is used in most system operations, and also provides the hard copy results of interactive lesson administration and other reports. The card reader and line printer were supplied by General Automation as an option to the RTOS II package. For a more detailed description of this equipment, refer to the General Automation SPC-16 System Reference Manual. (3)

The special controllers necessary to interface the scanning receiver and CDS transmitter were built and supplied by Coaxial Scientific Corporation. The controllers necessary to interface the headend video equipment and the minicomputer are standard General Automation general purpose input/output controllers. A more detailed discussion of the functions of these special controllers follows.

Headend Video Equipment

Video equipment at the cable system headend includes two Sony VO-2600 VCRs; two character generators (Telemation and 3M) for alphanumeric message display; two Shintron 367 timecode units for recording and reading timecodes on the videotapes; and the Michigan State University Timecode Interface and Video Switcher Controller which enables the minicomputer to control and receive timecode data from the VCRs, as well as to control all VCR functions and the outgoing video signal. (See Figure 5-2.)

The Michigan State University Timecode Interface and Video Switcher provides the necessary link between minicomputer and video equipment which makes the two-way instructional system completely computerized. (See Figure 5-4.) It enables synchronization of the videotape and computer operations for the interactive lessons.

The timing operation begins by pre-recording the SMPTE timecode information on the first audio track of each videotape using the timecode reader/generator. Hours, minutes, seconds and frames of tape time are digitally encoded for each frame of the videotape. During the actual lesson administration, the timecode track of the videotape is played back and decoded by the timecode reader, and presented to the interface unit in multiplexed form. The interface unit demultiplexes the data and makes it available to the minicomputer. The minicomputer is preprogrammed with times at which interactive items are to occur during a lesson. The lesson processor program which coordinates the lesson administration continuously checks the running timecode supplied by the interface against the pre-programmed interactive codes. If they are equal, the processor executes a routine for interactions.

A key feature of interactive items is instant feedback provided by the computer in the form of character-generated messages. In order to provide this display, the videotape must be paused, and the video output line switched to the character generator. The Interface-Video Switcher provides this capability by sending signals to the VCR through an external IOS (General Automation's Input/Output System) driver. In this manner, signals of forward, stop, rewind, fast forward, pause, VCR video source and character-generated video source can be sent to the VCR by the minicomputer.

A more technical discussion of the interface may be found in Appendix V-1.

Figure 5-3. HEADEND MINICOMPUTER CONFIGURATION

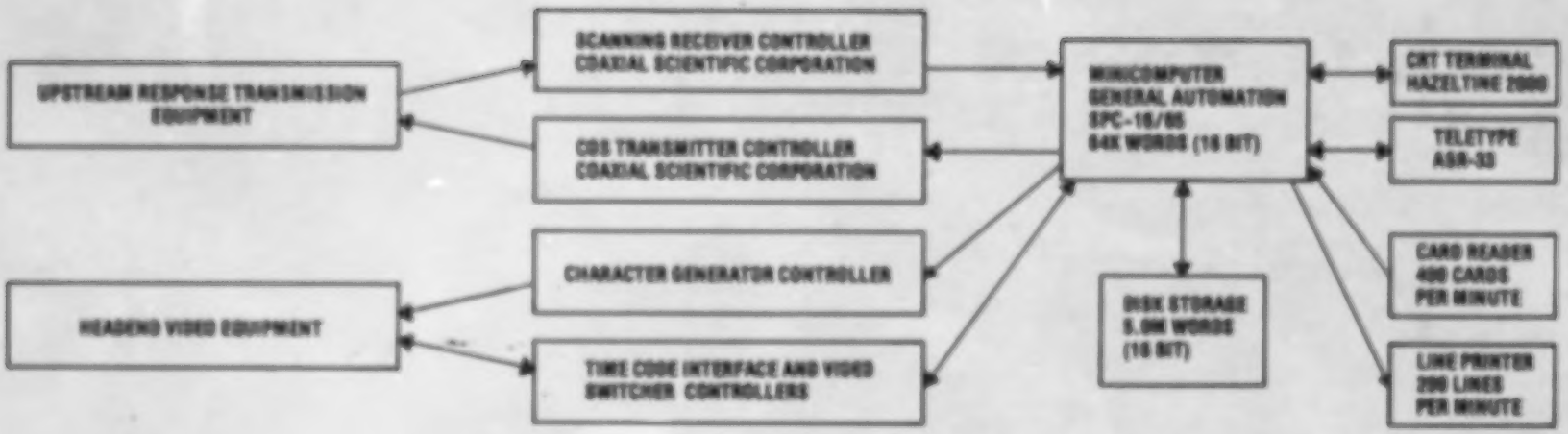
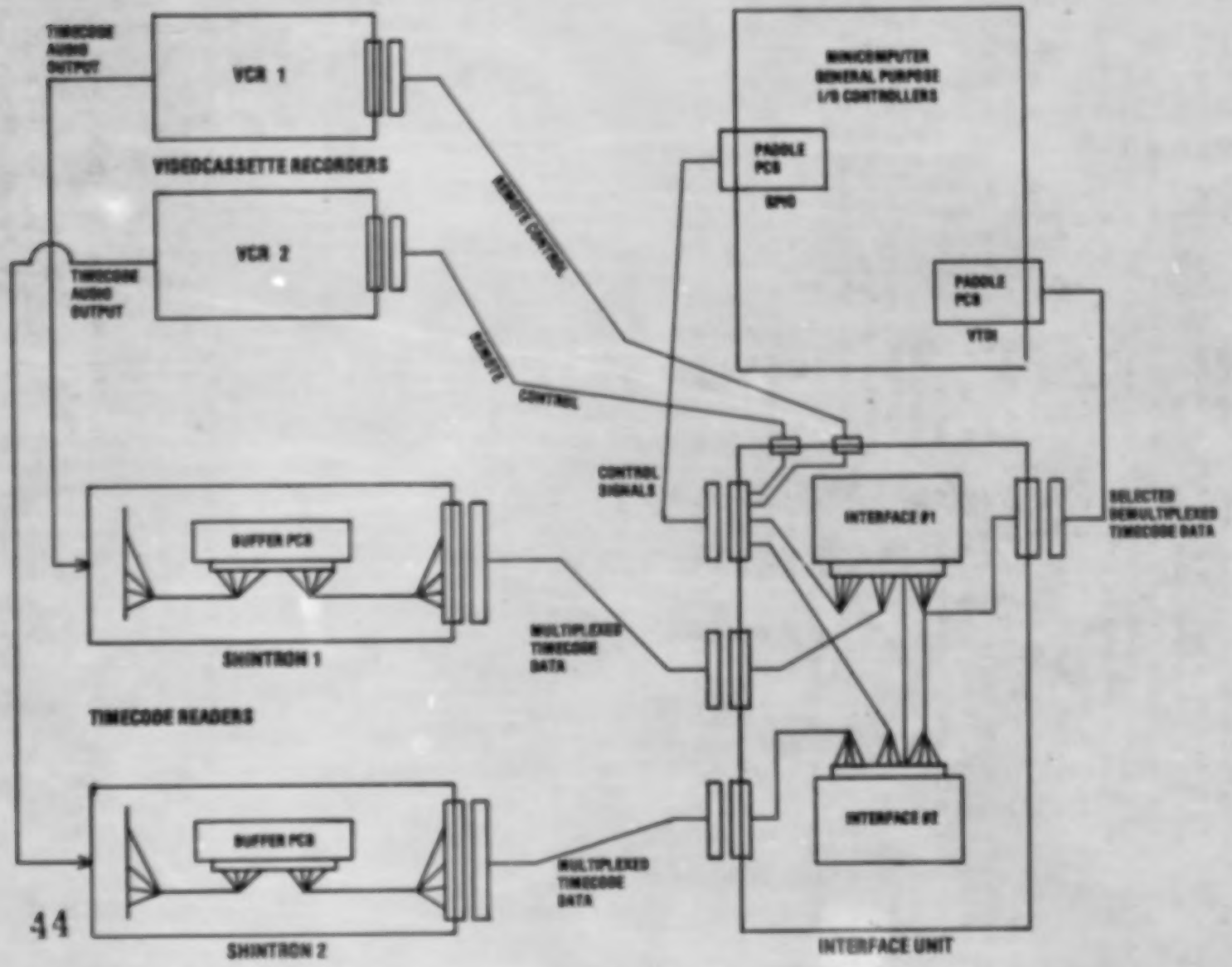

UPSTREAM RESPONSE TRANSMISSION EQUIPMENT
SCANNING RECEIVER CONTROLLER COAXIAL SCIENTIFIC CORPORATION
CDS TRANSMITTER CONTROLLER COAXIAL SCIENTIFIC CORPORATION
CHARACTER GENERATOR CONTROLLER
HEADEND VIDEO EQUIPMENT
TIME CODE INTERFACE AND VIDEO SWITCHER CONTROLLERS
MINICOMPUTER GENERAL AUTOMATION SPC-16/65 64K WORDS (16 BIT)
DISK STORAGE 5.0M WORDS (16 BIT)
CRT TERMINAL HAZELTINE 2000
TELETYPE ASR-33
CARD READER 400 CARDS PER MINUTE
LINE PRINTER 200 LINES PER MINUTE

Figure 5-4. SYSTEM CABLING TIMECODE INTERFACE AND VIDEO SWITCHER



System Software

The software resident on the minicomputer, written in FORTRAN and General Automation assembler CAP-16, supports not only the administration of interactive video lessons, but also provides complete facilities for preparing computer interaction scripts and files for each lesson, for maintaining a working image of the cable network, and for managing student records and preparing statistical reports on completed interactive lessons. (See Figure 5-5.) The system design provides completely automated lesson administration, requiring the headend operator merely to load the current lesson videotape into the VCR and to initiate the lesson processor program by entering the lesson name and number via the CRT keyboard.

Lesson Processor Preparation

The lesson processor program ($LESSON)[1] consists of 40 subroutine modules which control hardware functions, file access, terminal addressing, log-ins and scanning, timing and lesson summaries. Six user-created data files must be established by system utility software in preparation for lesson administration by $LESSON: (1) NETWORK - a list of all primary and secondary COSs and terminals in the cable system; (2) TIMECODE - an array of timecodes marking interactive cueing points; (3) RECORD - a file of student responses for the lesson; (4) IDENT - a list of specific information for a lesson; (5) ITEM - a series of parameters for each interactive item in the lesson; and (6) TEXT - question and response texts to be displayed by the character generator during a lesson.

The NETWORK File

NETWORK is an indexed sequential access (ISAM) file, established by using General Automation's File Management System (FMS), which contains a listing of all possible terminals which might be scanned during the lesson administration. An integer array, it can accommodate up to 80 six-word listings which contain the number and frequency of both primary and secondary code-operated switches, as well as the terminal frequency and fire station. Terminals can be added or deleted from the file at any time using the system utility program $SYU.

The TIMECODE File

TIMECODE is an FMS ISAM file of videotape timecodes which are used to synchronize the video lesson with its corresponding computer interactions. A timecode generator/reader interfaced with the minicomputer records and reads the timecodes on audio channel 1 of a dual-track videocassette. Each record in the TIMECODE file, an integer array for each lesson, can accommodate 80 four-word timecode values which contain lesson number[2], minutes, seconds and frames for each cueing point.

The operator creates the TIMECODE files for a particular lesson by using utility program $VIDCU2. While viewing the videotape, console key is depressed at each point of interaction, causing the timecode reader to read the timecode, which is then stored in the TIMECODE array. During the actual lesson administration, this TIMECODE array will be checked against the running timecode on the videocassette to locate interactive points, which occur when the two timecodes are equal. These points include: (1) the initial point to switch to the videotape and begin the lesson; (2) the point to start looking for audience response for a normal question; (3) the point to display feedback for each normal question; (4) the point to start looking for responses for quick quizzes; (5) the point to display a quiz score at the end of the quiz; (6) the point to display a lesson score; and (7) the point to end the lesson and rewind the tape.

The RECORD File

The RECORD file contains a byte array called ANSWER for each lesson, which contains a listing of responses to each interactive item by ID code, a "key" of correct answers for the lessons and an attendance code. The array can accommodate 126 student sub-records per lesson; the first sub-record is used for the "key." Bytes 1-3 of each sub-record contain the student's ID code, while bytes 6-30 contain responses for each item. Byte 4 is used to indicate the status of the student for the particular lesson (0 if ID has not taken the lesson; terminal number if ID is currently taking the lesson; blank if ID has taken the lesson). The utility program $RECORD establishes an empty record array for each lesson using a roster of student ID's to create each sub-record; the lesson processor fills in the key and student responses in the course of lesson administration. Software to change student responses, and to add or delete an ID code from a lesson record, is also available.

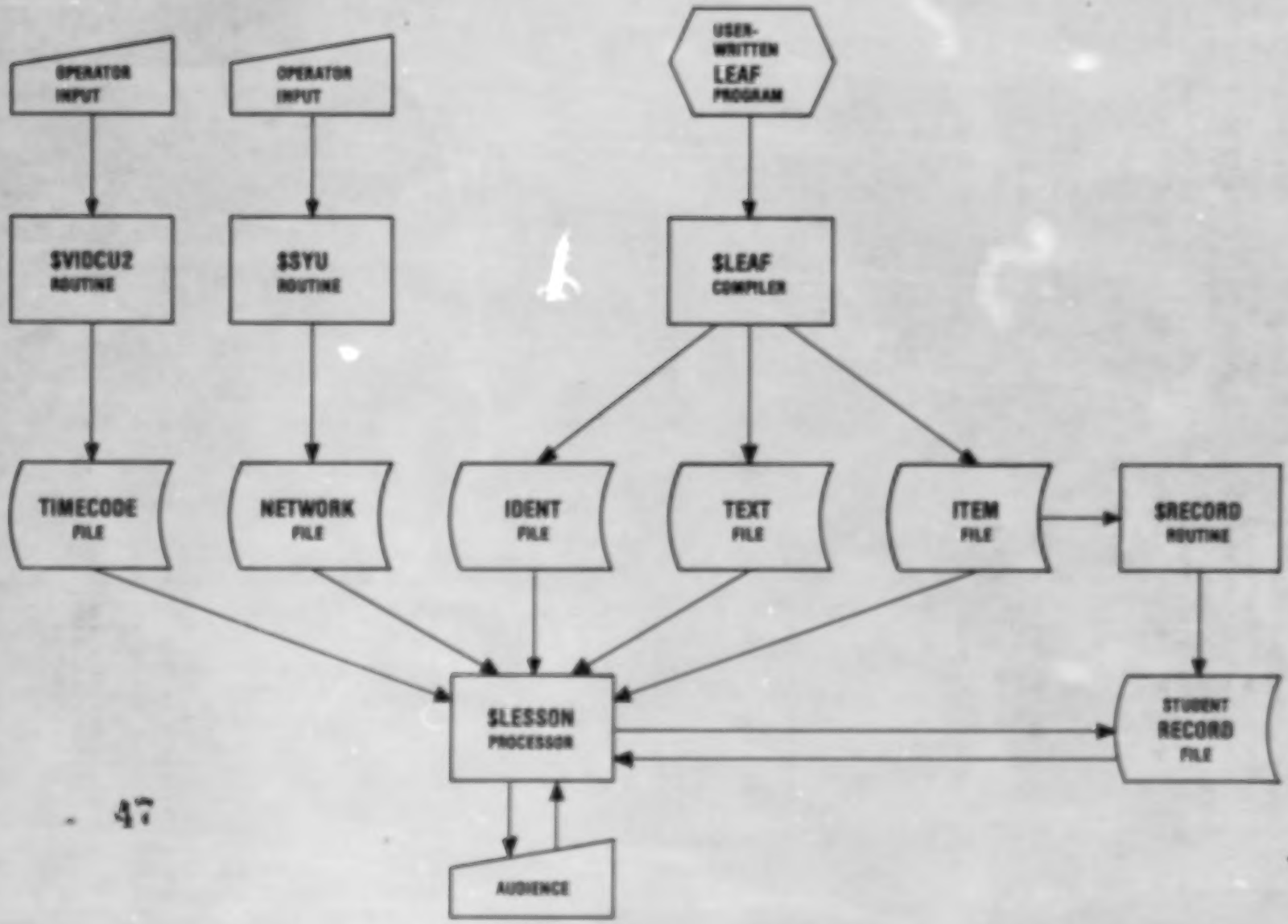
The LEAF Program—the IDENT, ITEM and TEXT Files

LEAF (Language for Educators And Firefighters) is a computer language developed especially for use

1. The GA minicomputer executive system designates main programs by a "$" preceding the lesson name.

2. Since no videotaped lesson was longer than one hour, the "hours" portion of the SMPTE timecode was used to encode the lesson number.

Figure 5-5. SYSTEM INFORMATION FLOW



in the Michigan State University-Rockford instructional system. It is highly user-oriented and allows the lesson author to convey information about interactive items in the lesson to the lesson processor. A Michigan State University-designed LEAF compiler processes each LEAF lesson program, establishing the IDENT, ITEM and TEXT files used by $LESSON.

A LEAF program consists of three sections: Initialization, Configuration and Report. The LEAF format is designed so that the Configuration section parallels the audio-video production script for the corresponding lesson. Figure 5-6 presents a complete LEAF program for that lesson. A sample page from an actual lesson script is given in Figure 5-7.

Figure 5-6. SAMPLE LEAF PROGRAM

```
IDENT
*
*  THIS IS A SAMPLE LEAF PROGRAM
*  FOR THE LESSON ON VERTICAL
*  STRUCTURES, WHICH IS PROGRAM 4
*
*  INITIALIZATION SECTION
*
NAME: VERTICAL STRUCTURES
ILIST: 18
DATE: 812777
AUTHOR: ERIC SMITH
ROLL: MASTER
GENERATE
*
*  CONFIGURATION SECTION
*
*  THE FIRST 6 ITEMS ARE MULTIPLE CHOICE
*
BEGIN
CALL
ITEM 1 M(2,4,3)
HEAD WHAT PERCENTAGE OF THESE
     FIRES OCCURRED ABOVE
     THE 5TH FLOOR?
FOIL  A  27%
FOIL  B  35%
FOIL  C  44%
FOIL  D  53%
ECHO I.X
ITEM 2 M(1,3,2)
HEAD IDENTIFY THE STRUCTURE
FOIL
      A  OPEN STAIRWAY
FOIL  B  ENCLOSED STAIRWAY
FOIL  C  SMOKE-PROOF TOWER
ECHO I.X
*
*  ITEMS 3 AND 4 USE AN EXTERNAL
*  VIDEO SOURCE.  THEY DO NOT HAVE
*  HEAD OR FOIL STATEMENTS
*
ITEM 3 M(5,4,1)
ECHO I.X
ITEM 4 M(5,4,4)
ECHO I.X
ITEM 5 M(2,4,2)
HEAD WHICH OF THE FOLLOWING
     STATEMENTS IS TRUE?

FOIL  A  THIS ELEVATOR HAS
         FIREMAN'S SERVICE
FOIL  B  THIS ELEVATOR WAS NOT
         DESIGNED FOR FIRE
         DEPT. OPERATION
FOIL  C  THIS ELEVATOR HAS A
         PHOTO CELL TO DETECT
         FIRES
FOIL  D  THE FIREMAN'S SERVICE
         KEY WILL OPERATE THIS
         ELEVATOR.


ECHO I.X
ITEM 6 M(4,3,1)
HEAD WHAT IS THE LOCATION OF
     THE ELEVATOR?
FOIL
      A  MAIN FLOOR WEST LOBBY
FOIL  B  BASEMENT LOADING DOCK
FOIL  C  1ST FLOOR LAUNDRY ROOM
ECHO I.X
*
*  THE NEXT TWO ITEMS ARE DICHOTOMY ITEMS
*
ITEM 7 D(2,1)
HEAD DOES THIS ELEVATOR HAVE
     FIRE DEPARTMENT SERVICE?
FOIL  A  YES
FOIL  B  NO
ECHO I.X
ITEM 8 D(2,2)
HEAD WHAT IS THE TYPE OF THE
     ELEVATOR?
FOIL  A  HYDRAULIC
FOIL  B  CABLE-SUPPORTED
ECHO I.X
ITEM 9 M(3,4,4)
HEAD WHICH FLOORS DOES THIS
     ELEVATOR SERVICE?
FOIL
      A  1ST FLOOR - 12TH FLOOR
FOIL  B  1ST FLOOR - 7TH FLOOR
FOIL  C  BASEMENT - 12TH FLOOR
FOIL  D  BASEMENT - 7TH FLOOR
ECHO I.X
*
*  QUICK QUIZ ITEM IS NEXT
*
ITEM 10 Q(5,10,2,1,2,3,2,2,2,3,1,2)
STOP
*
*  REPORT SECTION
*
REPORT
TITLE
HIST
FREQ
 END
```

Figure 5-7. AUDIO-VIDEO-COMPUTER PRODUCTION SCRIPT LESSON 4 "VERTICAL STRUCTURES"

VIDEO	AUDIO	COMPUTER
Take slide of question mark. 2-shot with talent, down stage with R.P. over right shoulder		
Lap several slides of enclosed stairway. (36,37,38)	QUES. VOICE: Now that we have looked at stairways, enclosed stairways and smoke-proof towers, let's see if you can identify the following structures.	
SUPER: IDENTIFY THIS STRUCTURE (R.P., 39)	Here is a look at a structure in a high-rise building.	
Hold last slide. Lose super.	Notice the diagram which shows its location.	
	What type of vertical structure have we just looked at?	
Super Wipe (40, R.P.) A. OPEN STAIRWAY B. ENCLOSED STAIRWAY C. SMOKE-PROOF TOWER (Hold 10 sec.)	A., open stairway B., an enclosed stairway, or C., a smoke-proof tower?	
	BEEPS	Stop Tape. COMPUTER-CHARACTER GENERATOR FEEDBACK BY CODES Start Tape.
Take talent in studio (#41) with R.P. First slide of enclosed stairway on R.P.	TALENT: Now, let's take a look at the pictures again.	
Dissolve through slides of enclosed stairway. F.C. (42,43)	Notice that this structure is completely enclosed and is separated from the rest of the building by single fire-rated doors.	
SUPER: "B. ENCLOSED STAIRWAY." R.P. (44)	This is an enclosed stairway. You should have selected choice B.	

The *Initialization Section* consists of a list of statements which contain the name of the lesson, number of interactive items in a lesson, the date, lesson author, equipment used during the lesson and whether the interactive item text will be displayed by the character generator. A maximum of 14 allowable equipment codes is permitted. The presence of a GENERATE statement is a signal to the LEAF compiler to store question and answer texts as a record for that lesson in the TEXT file. All information obtained in the Initialization section for a particular lesson is stored by LEAF as a record in the IDENT file.

The *Configuration Section* contains an ITEM BLOCK for each interactive question in the lesson, giving the ordinal of the current item, type of question (multiple choice, ranking, dichotomy, quick quiz), color for the background of any character-generated text, number of foils and the correct answer. This information is stored for each item in each lesson as a record in the FMS file ITEM. If the text of each item is to be displayed by the character generator (indicated in the Initialization section), the ITEM BLOCK also includes HEAD and FOIL statements, which give the text for each item, stored in the TEXT file. Each HEAD and FOIL can occupy two 30-character lines, with a maximum TEXT file size for each lesson of five disk sectors.

The final configuration section command is ECHO, an option which allows for immediate response feedback after an interaction has occurred. ECHO information, passed to the lesson processor via FMS file IDENT, displays via the character generator a breakdown of student responses to each item in various formats: for each foil, the number of percentage of respondents, or if desired, a listing of their ID codes. (See Feedback #1, #2 and #3, Chapter 3.)

The *Report Section* is a series of statements specifying the types of printed reports to be generated at the headend at the end of the lesson: TITLE prints IDENT information, current data and time, and a list of individuals participating in the lesson; FREQ prints a frequency distribution of items, while ANAL prints an item analysis and HIST calls for a cumulative frequency distribution of items. For the Rockford firefighter training experiment, these commands were inoperative. Report generation was included as part of the main lesson processor program.

Once the six system files have been established, system information about the lesson is completed. The lesson may be shown at any time by inputting the lesson name and number to the lesson processor program $LESSON. The program accesses all of the stored data and manages all interactions, including starting and stopping the VCR, transferring video output to the character generator, scanning the terminals and providing instant response feedback. The processor program also updates the student RECORD file.

The Lesson Processor ($LESSON)

To begin executing a lesson, $LESSON (See Figure 5-8) first retrieves necessary lesson information from FMS files IDENT, ITEM, TEXT, NETWORK and TIMECODE and creates appropriate arrays for the data. Next, in preparation for the log-in procedure, it switches video output to the character generator through the computer-controlled video switcher.

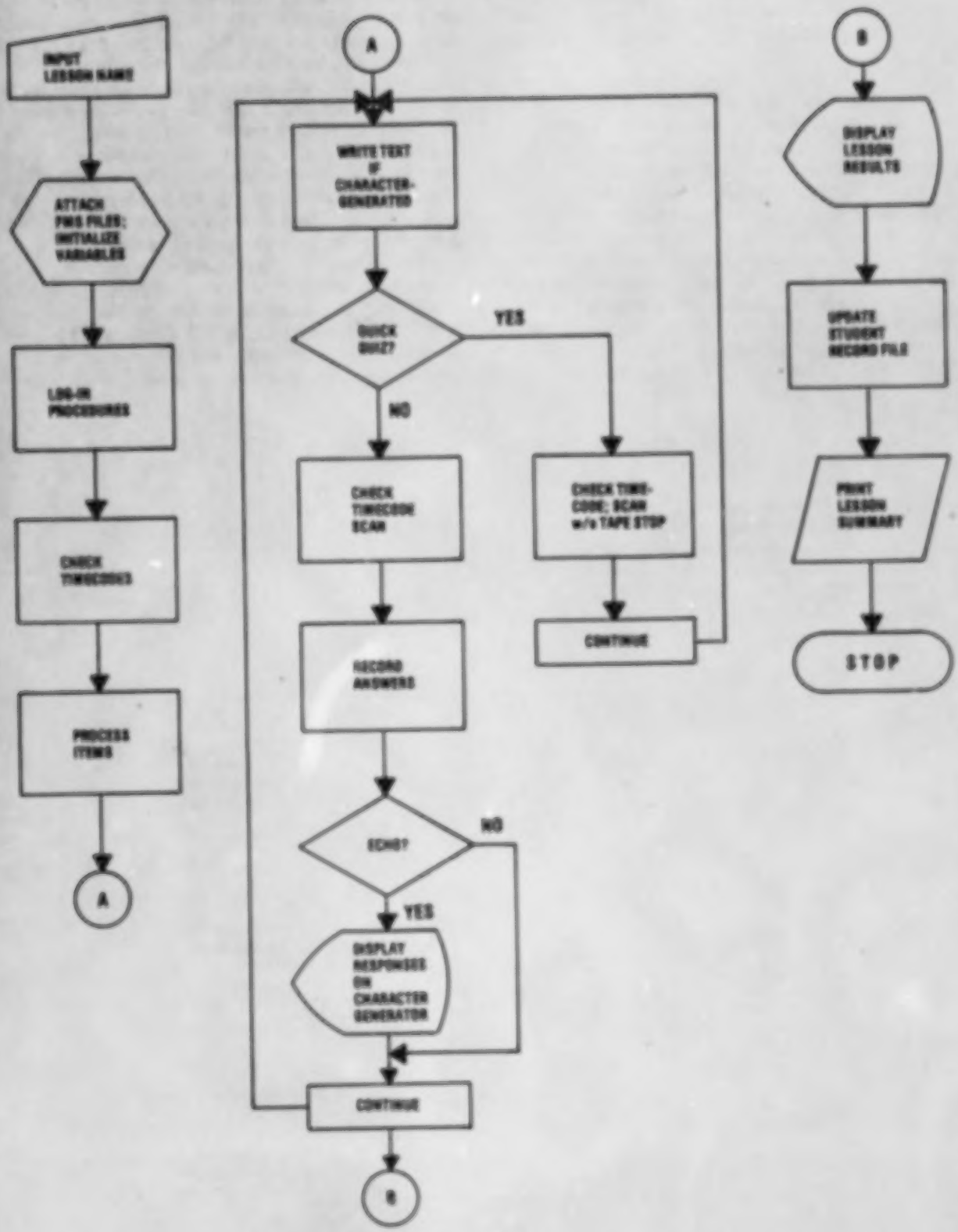
The log-in procedure, during which respondents enter a three-letter ID code, one letter at a time, using their response terminals, is one of the more complicated routines of the lesson processor in terms of hardware/software interaction. The subroutine LOGIN, which calls eight other subroutines during execution, controls the operation, which first writes a log-in message to respondents on the character generator and sets a five-minute limit for the procedure to be completed. The program then uses NETWORK file information to set scanning flags for all terminals in the system to be scanned.

The scanning routines begin by addressing the primary and secondary COSs controlling each network sector (refer to Chapter 2), by sending a signal at the correct frequency to open the corresponding switches. The individual terminals in each sector are then scanned for data, which are decoded and converted to their computer code equivalent. Appropriate signal level checks are made to insure good transmission of data.

Since the log-in procedure involves a three-letter ID, each terminal must be scanned three times to collect the full identification code. A respondent can cancel an erroneous entry and log-in again with the correct ID. More than one respondent can log-in from a single terminal; subsequent responses from that terminal during the lesson are credited to each member of the group. Each three-letter code is checked against the master list of ID's from the student RECORD file and displayed on the television screen by the character generator to confirm that the log-in has been accomplished. In addition, the routine stores the terminal number of each respondent in the attendance byte of his subrecord in the ANSWER array to indicate that the student is currently taking the lesson.

Having completed the log-in, the lesson processor sends a forward command to the VCR, and the lesson videotape begins. At this point the processor begins checking the current time codes on the videotape with the next sequential value in the

Figure 5-8. LESSON PROCESSOR

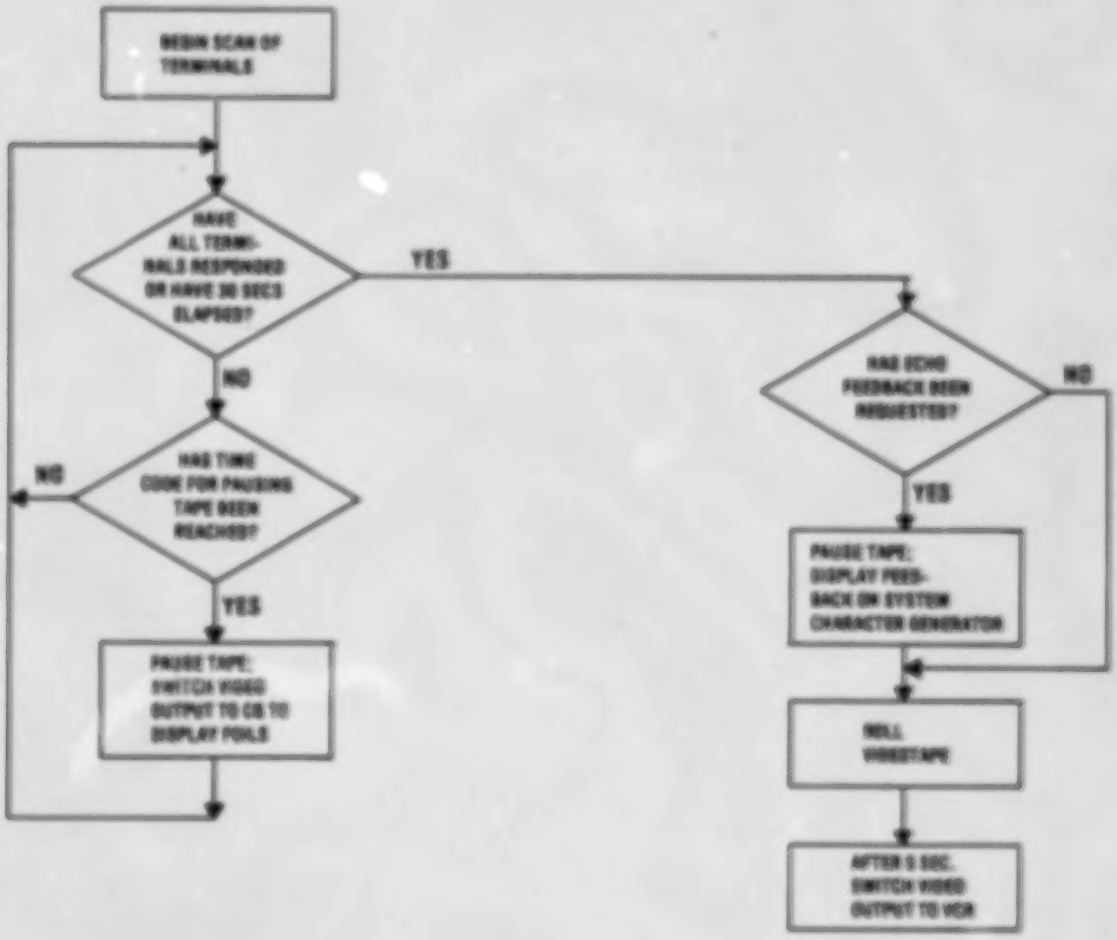


TIMECODE array. This timing sequence continues until the running timecode equals or exceeds the stored timecode value. The pointer in the timecode array is then advanced and the processor begins an interactive item.

At each interactive point in the lesson, the processor retrieves necessary question information, such as question type, number of foils, background color and ECHO information from the ITEM file. Scanning flags are set for those terminals entered during the log-in; the program then scans those terminals for responses and stores answers in the data array ANSWER. Questions and foils are included as part of the lesson videotapes in the Rockford firefighter experiment. If all terminals transmit responses while the question is displayed on the running videotape, the tape is paused only when character-generated feedback is requested through the LEAF ECHO option. However, if respondents are slow in transmitting their answers, the processor stops the tape and switches the video output to the character generator, which displays question and foils retrieved from the TEXT file. (See Figure 5-9.) In either case, the time at which the tape should be paused is found as a cueing point in the TIMECODE array. The processor also checks for missed responses from each terminal. If a respondent fails to register on two consecutive items, the scanning flag for that ID is turned off, and the terminal is no longer scanned for data. This option was frequently used during the Rockford experiment, when firefighters left their station in response to a fire alarm!

If the lesson author requested immediate item feedback in the LEAF program, it is displayed by the ECHO routine. Depending on the specified user option, ECHO checks the ANSWER array for all lesson respondents and displays the information in the chosen format; e.g., number responding to each foil.

Figure 5-9. EXECUTION OF AN INTERACTIVE ITEM


BEGIN SCAN OF TERMINALS
HAVE ALL TERMINALS RESPONDED OR HAVE 30 SECS ELAPSED?
YES
NO
HAS TIME CODE FOR PAUSING TAPE BEEN REACHED?
NO
YES
PAUSE TAPE; SWITCH VIDEO OUTPUT TO CG TO DISPLAY FOILS
HAS ECHO FEEDBACK BEEN REQUESTED?
NO
YES
PAUSE TAPE; DISPLAY FEEDBACK ON SYSTEM CHARACTER GENERATOR
ROLL VIDEOTAPE
AFTER 5 SEC. SWITCH VIDEO OUTPUT TO VCR

percentage responding to each foil, individual responses by ID code. The routine pauses the videotape (if it has not already been paused during the scan) and switches video output to the character generator to display the feedback. At the end of the display, the processor releases the videotape, waits five seconds and then returns video output to the videocassette player. This masks the jumpy video signal which occurs when the VCR is taken off pause. The videotape lesson continues until the next interactive point is found by the timing program.

In addition to processing single interactive items, LEAF is also designed to permit a series of questions in rapid succession, with limited response time, uninterrupted by feedback between questions. This "quick quiz" option, first designated in the LEAF program for the lesson, is identified to the lesson processor at the time of the interaction. A special scan, which allows only five seconds per response and does not stop the videotape, records answers. At the end of the quiz, a cumulative ECHO reports percentage scores for the entire quiz.

When it has executed the given number of interactive items in the lesson, the processor begins its closing operations. A printed lesson summary is generated, listing individual scores and item-by-item response, as well as an item analysis of test questions. The ECHO routine displays a final percentage score for each student taking the lesson, and then, in the firefighter training application, computes and displays the average score for each firefighter on a particular shift. In addition, the processor transfers student responses in the data array ANSWER to permanent disk storage on file RECORD. As its last timing function, the processor checks for the end of the tape, issues appropriate commands to the VCR to stop and then rewind the tape and sends an end-of-lesson message to students via the character generator.

Summary

The minicomputer software system described here combines the advantages of television and computer-aided instruction for potentially large numbers of students at relatively low cost. Using technological developments in two-way cable delivery and computer-hardware interfaces, the system automates the interactive lesson administration and maintains accurate, up-to-date records of student attendance and progress throughout an entire series of lessons. At the present time, with current terminal addressing systems, video equipment, minicomputer memory and the "mass" character of the audience, the interaction in each lesson are, of necessity, limited. The full dimensions of computer-assisted instruction, with more complicated branching, repetition and feedback, remain to be explored and developed for use by two-way cable television systems.

The present system has been employed to provide in-service training of firefighters and teachers in Rockford, Illinois. System components, such as file structures, the LEAF language and compiler, and the lesson processor itself are designed for easy adaptability to any type of instructional lesson and are readily understandable by non-computer personnel.

For a complete description of the Michigan State University-Rockford system software configuration, refer to a separate volume to this report, which contains complete programming documentation. (2)

Notes — Chapter 5

[1] General Automation, Inc., *SPC-16/85 System Reference* (88A00243A-D), February 1974.

[2] Martin P. Block, John B. Bulemberg, Eric S. Smith and Jayne W. Zenaty, *Michigan State University-Rockford Two-Way Cable Project: Minicomputer System Software*, Volume III, Final Report, NSF Grant No. APR 75-14286, June 1978.

Chapter 6

Cable System Technology and Performance[1]

Upstream Response Transmission Equipment

The Michigan State University-Rockford Cable Project represents the successful application of the first and second generation two-way cable technology described in Chapter 2. The Rockford Cablevision plant is a four quadrant, single trunk line cable system. The upstream response subsystem consists of control devices at the cable system headend, primary code-operated switches (P-COS), secondary code-operated switches (S-COS), response terminals and test end-of-line test oscillators (ELO). (See Figure 6-1.) The two COSs generate identification signals which are used to confirm their activation. These signals are transmitted to the cable system headend along with an FSK-modulated terminal signal and the ELO signal.

The Rockford system departs from usual system design in one important respect—the feeder cable upstream path passes only the 5 to 10.5 MHz spectrum, while frequencies of 12.5 MHz and above are attenuated by 25 db or more. The trunk cable passes the full 5 to 30 MHz, which includes the feeder data signals. This feeder cable bandwidth limiting, together with the technique of feeder switching developed by Coaxial Scientific Corporation, and quadrant switching, has brought electrical interference, short-wave signal intrusion and system amplifier-cascade noise down to manageable levels.

The minicomputer discussed in Chapter 5 sequentially interrogates the response terminals in the field by (1) transmitting coded FSK (frequency shift keyed) signals at 112 MHz to addressable receivers located in the P-COSs and S-COSs, which select quadrant and amplifier, and (2) by tuning one-by-one through the various terminal FSK signals, identifying each terminal by its unique combination of COS, ELO and terminal frequencies.

All return signals from each quadrant, shown in Figure 6-2, are split to allow use of television Channels T-8 or T-9, and of non-switched data signals in the T-10 band to be used separately, while the switched feeder return signals are isolated by a 5 to 10.5 MHz low pass filter and routed to a diode switch operated by the minicomputer-controlled P-COS. A P-COS identifying tone is made to go through this switch as verification of its operation. Feeder-return diode-switch outputs from all quadrants are brought together (with only one "on" at a time), and after passing through a second filter and an amplifier, are fed to the FSK receiver.

At any instant of terminal interrogation, about 4,000 feet of feeder cable, 9,000 feet of trunk cable and 15,000 feet of subscriber service cable (i.e., 40 subscribers) are "on" and are a potential source of short-wave radio or electrical interference. The system is designed to survey only one quadrant of the plant at a time, which drastically reduces upstream, on-line interference from the remaining three quadrants. In addition, during this experiment, the amount of feeder cable and the subscribers-per-amplifier count were both low due to the "turning-up" of only enough amplifiers to create the desired return path. A normal fully operational amplifier would have about 8,000 feet of feeder and 65 subscribers with an ingress-exposure factor about twice as large.

The amplifier and S-COS configuration used in Rockford is shown in Figure 6-3. A Magnavox 4-MS-2 series amplifier was factory modified (1) to limit the feeder return to the 5 to 10.5 MHz frequency band, and (2) to include a feeder return disable capability which is accessed through the amplifier's unused seventh port. A modified COS incorporates the FSK receiver and addressable logic which provides the control voltage to the feeder return switch. This S-COS also injects a special frequency into the return path which functions for test and identification purposes. Finally, the terminal, as shown in Figure 5-1 of Chapter 5, houses an FSK transmitter which is "on" all the time and which is modulated by activating any of several push-buttons, including the added transmit button, on the modified Jerrold SX-2. This causes a data word, which is also continuously transmitted, to change its content accordingly. The ELO is a test signal transmitter located, as its name implies, at the end of the line. This signal is simply monitored for its presence and amplitude.

1. This chapter was written principally by James Wright, Martin Block and Robert Yadon.

Figure 6-1. QUADRANT MULTIPLEXING

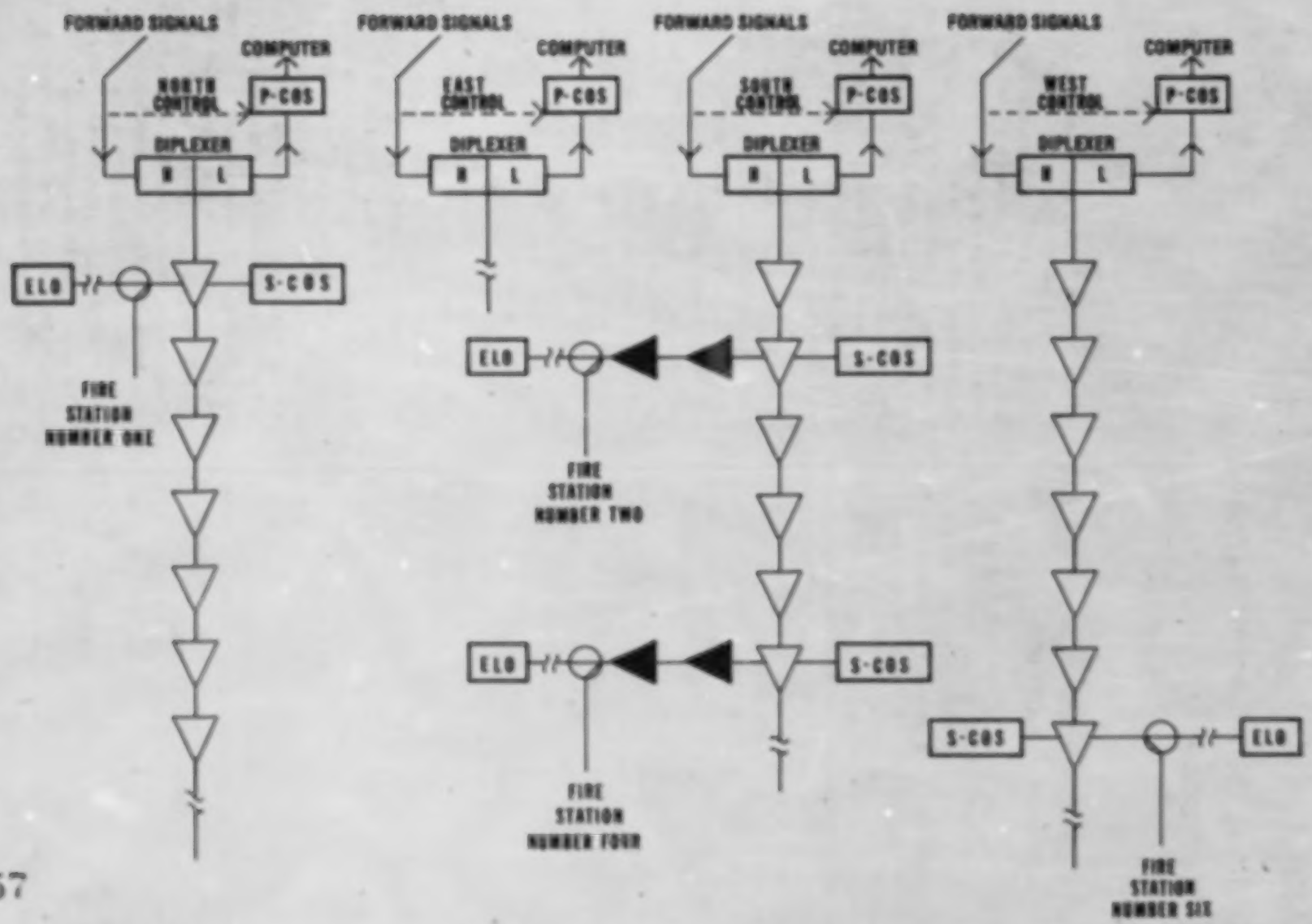


Figure 6-2. TYPICAL HEADEND RETURN-CIRCUIT CONTROL

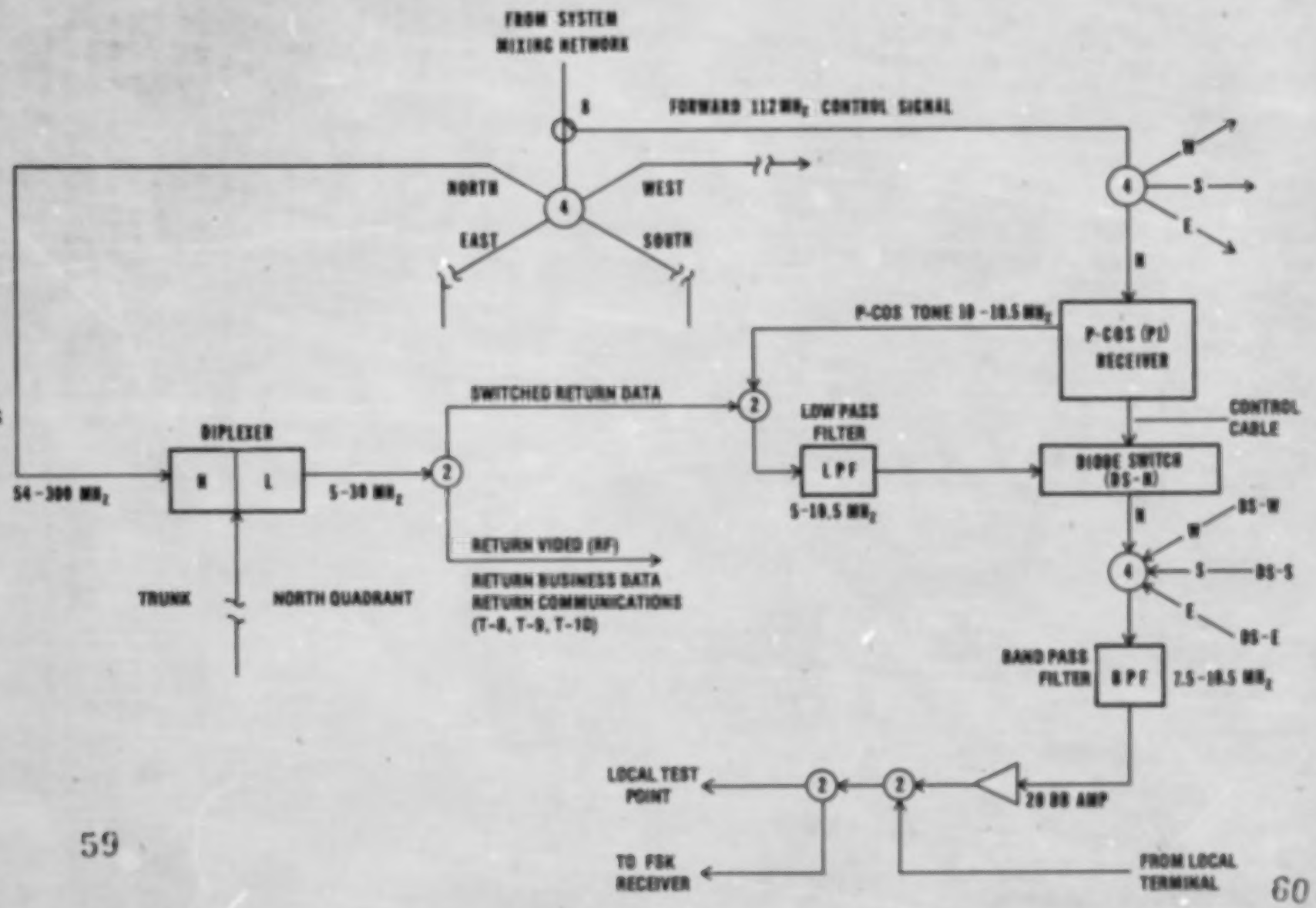
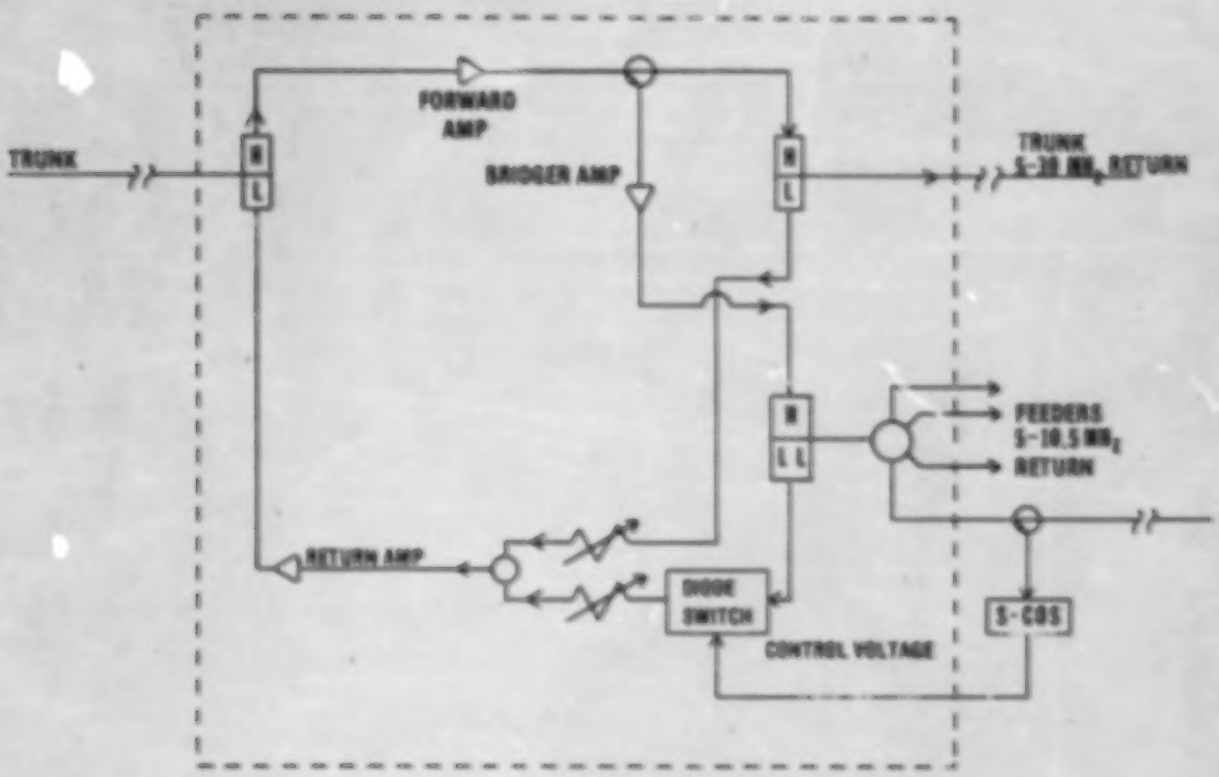


Figure 6-3. COS/AMPLIFIER STATION



Distribution Plant Design Precautions

In anticipation of the then known problems attendant to two-way cable, Rockford Cablevision system designers were especially attentive to factors which could contribute to cable interference intrusion (or ingress) and affect the upstream signals.

The active and passive equipment selected for the system (amplifiers, directional couplers, tap-off units, power-insertion units) had high RF shielding over the entire frequency spectrum, from well below 5 MHz to well above 300 MHz. A shielding effectiveness of 140 to 150 db was the minimum acceptable rating. Trunk and feeder cable fittings had similar shielding ratings accomplished in part by using available steel cable insert s eeves. It was important that the fitting seize and ho d the cable so securely that the two became as on e so as to prevent any relative movement. Too mu :h pressure would result in metal deformation and "cold-flow," so it was important that torque wrenches be used to tighten all fittings. As a further precaution against fitting problems, the Rockford system uses two full-sized, flat-bottomed expansion-loops at each utility pole. This provides more protection than necessary to prevent cable rupture from flexing fatigue, but it virtually eliminates forces acting on the fittings from cable flexing, twisting and expansion and vibration, thereby removing the major cause of loose fittings.

Service drops are the most difficult of potential interference ingress sources to control: first, because there are more miles of such cable, and second, because the system is at the mercy of the subscriber after the cable enters the home. The subscriber will very likely abuse the cable near the TV set, due to normal home activities, with the result that system shielding can approach zero at this point.

Rockford selected the eight-mil bonded construction type of cable as the only one available at the time which provided sufficient shielding at low cost. Long ferruled fittings using a hex-crimp crimp-ring were selected, and the cable was installed using loops which, in this application, were designed to prevent vibration from causing metal fatigue. At the ground-block, the eight-mil cable ended and a double-braided cable continued on to the wall-plate

and to the matching transformer. In a final effort to minimise "ingress," TV matching transformers of the "high-pass" variety were selected, and in the case of 75 ohm sets, a separate high-pass filter was installed. These devices provide a low frequency rejection of 25 to 40 db reading from 30 to 5 MHz.

Cable System Performance

The manufacturer's specifications for upstream television signals call for return amplifier output levels of +30 dbmv for four channels. This level generates extremely low intermodulation products and, in the Rockford system of switched feeders, results in an intrinsic signal-to-noise ratio of about 50 db. A change in level setting techniques should be mentioned here, in which one uses the return amplifier inputs as the equalization and control point, rather than the amplifier outputs, as in normal forward transmission. This is mandated by the multiplicity of signal sources arriving at the amplifier via different paths of random lengths and attenuations.

The +30 dbmv television signal was used as the starting point and four such signals accepted as the desired amplifier loading. By assuming a 9 db gain as required for a "worst case" situation, an amplifier input of +21 dbmv for television becomes the specified level for the trunk return-amplifier television signal inputs.

Assuming a 10 KHz data signal bandwidth, and a 10 KHz guardband, a 4 MHz television channel (Note: 4 MHz vs. 6 MHz is intentional.) will accommodate 200 200 such data channels. By operating these 200 channels at -2 dbmv (amplifier input), the amplifier will be loaded approximately as heavily as with one television channel at +21 dbmv, and this becomes the specified level for a 10 KHz data-signal trunk return amplifier input. Line extender amplifiers are operated at a +1 dbmv input, based on the output capabilities of the various signal sources and system losses.

From these input levels, the maximum permissible interference levels for each of the types of noise may be determined. Table 6-1 below indicates various interference levels measured over the two types of service, television and data.

Table 6-1. Interference Levels by Type of Service

Type of Service	Trunk Amplifier Input Level (dbmv)	Random Noise (dbmv)	Discrete Radio Signals (dbmv)	Electrical Noise (dbmv)
Television 4 MHz	+21	-28	-36	-25
Data 10 KHz	— 2	-22	-22	-22

As the nuisance value of the interference is frequency related, it is necessary to list the Rockford Cablevision frequency assignments for its return system. In Table 6-2 below, the spectrum allocation of the upstream portion of the system is indicated.

Table 6-2. Upstream Spectrum Allocation by Type of Service

Type of Service	Frequency Allocation From	To
Data Acquisition (Feeder and Trunk)	7.5 MHz	10.5 MHz
Voice, System Alarms (Trunk only)	5 MHz	7.5 MHz
Television (Trunk only)	11.75 MHz	23.75 MHz
Business Data (Trunk only)	23.75 MHz	30 MHz

While indicated as a separate service in Table 6-2, it should be noted that "voice" is used only in conjunction with the remote television services. Note also that the business data band will avoid the citizens' band (CB) at 27 MHz. Random noise, as an interference is dealt with in system design and will be no problem whatever for data if it satisfies the requirements of the television service.

Discrete radio interference is a major problem in the 5 to 15 MHz band, and again at 26.96 to 27.41 MHz (e.g., CB), and can be in the 15, 20 and 40 meter amateur bands. While FSK data and FM voice systems can tolerate interference ratios of 10 db, even up to 4 db, experience has shown that there is no problem holding this interference to at least the 10 db ratio and normally to a 20 db or greater ratio. Within the television channels used, T-8 and T-9, the major problem area is the 13 to 15 MHz range, and here again the desired -36 dbmv (-57 db ratio) can be achieved with reasonable maintenance measures due to essentially trunk-only exposure. The CB interference problem is nearly uncontrollable, and the goal became a two-fold one of avoiding the use of these frequencies, and of containing them sufficiently to prevent significant loading to the return system. The abandonment of the CB frequencies meant that television channel T-10 could not be used for television. The resulting split-band was assigned to the business-data service.

Electrical interference, at -22 dbmv measured at 10 KHz bandwidth for data, or at -25 dbmv calculated to a 4 MHz bandwidth for television, does not pose a serious problem. The greatest exposure area, the feeder cables, are able to tolerate the highest interference level in the system, and conversely, where the best protection is needed, at the trunk television frequencies, there is the most protection.

Distribution System Test and Maintenance Procedures

Initial "set-up" of the cable system return transmission path is accomplished by inserting a composite test signal (at 8, 9, 19 and 28 MHz) into the input of the last return amplifier (first forward amp) with all the frequencies at the same level (e.g., -2 dbmv). The display at the headend is monitored and the amplifier gain and slope controls are varied to achieve a "flat" display of an amplitude gain and with the losses built in between the amplifier and the test point. The "flat" display is logged and the field person then moves back to the next amplifier and repeats the procedure until the first return amplifier is reached. A technique is being developed to allow the field person to carry a small TV set and to remotely control the headend display, observing it while he or she adjusts each amplifier. Initially all signal sources (e.g., terminals, ELOs, TV modulators) must be set up using a two person team to assure that the amplifier input signals are properly balanced. The remotely controlled monitoring will serve this operational need as well as for initial amplifier "set-up."

Signal-intrusion into the "return" path of a cable is directly related to signal-radiation by the forward system. The nature of the system defect determines the magnitude of both the signal ingress and egress. The first step followed in de-ingressing is to carefully monitor the involved area with a "Sniffer" (Com Sonics) and to correct any observed radiation down to a level somewhat below the FCC radiation limits. After this a technician moves, one amplifier at a time, feeder-by-feeder, tap-by-tap and drop-by-drop, as necessary, correcting problems until the ingress is some 10 db better than the minimum. This procedure results in a rigorous testing of the overall integrity of the cable plant and reveals problems that are only marginally apparent, if at all, on the forward system. One end-result of de-ingressing the return system is better performance on the forward system.

Chapter 7

Preparation for Training and the Experiment[1]

In the experiment there were two conditions, two-way and one-way television training. Each condition included two treatments related to the response mode. In the two-way condition, two-way individual treatment participants each responded to interactive questions with a personal response terminal. In the two-way group treatment, a group of respondents used a single terminal to make a consensus response to questions. The one-way condition treatments included the one-way paper and pencil treatment where answers to the questions were circled by each participant on a prepared form, and the one-way covert response treatment where participants were asked only to make a mental note of the answers to the questions. Only the two-way condition treatments received feedback, as described in Chapter 3, on their responses. The conditions and treatments are described in more detial in Chapter 8.

Scheduling

In creating a program schedule for the experiment, several things were taken into consideration. Traditionally, the firefighters work a normal eight-to-five day even though they are present in their stations for 24 hours. The time after 5 p.m. is considered "free" in that the men are allowed to read, study, watch TV or do other things in the station house. To conform with the normal workday pattern, programs could only be scheduled during the 8 a.m. to 5 p.m time period.

An additional consideration was the possible order bias if one experimental treatment were consistently scheduled at a different time of day from another. For example, if all two-way programs were viewed in the morning and all one-way programs in the afternoon, "time of day" as a variable would be introduced and could influence the result. As a result, lesson times of 9:32 a.m. and 1:32 p.m. were agreed upon by Fire Department officials and the researchers. The morning and afternoon times were alternated among all treatments so that each firefighter saw five instructional tapes at 9:32 a.m. and five at 1:32 p.m. (Tapes #1 and #10 of the 12 videotapes were paper-and-pencil tests which all treatment groups viewed simultaneously.) Two cablecasts were scheduled for each program day, a one-way lesson and a two-way lesson.

Although the firefighters have a training period set aside for Saturdays and Sundays, activity is more casual than on weekdays. Fire Academy and other Departmental officers advised that weekend viewings would occur in a different atmosphere than weekday viewings and, therefore, might produce a different result for programs scheduled on weekends. On this advice, only Saturdays were included in the program schedule and then only for make-up lessons when the firefighters missed the cablecast on the primary viewing day.

Another necessity was administrative time for the distribution and collection of answer sheets and questionnaires and for the maintenance of records for the one-way stations. It was decided that Mondays could be used for this purpose. No lessons were scheduled on Mondays. (See Appendix VII-1, Program Schedule.) The Field Director physically "made the rounds" of the stations to distribute and collect the paperwork. The cost of this activity was a factor in comparing one-way and two-way treatments.

To facilitate record-keeping procedures within the project, each learner was given a three-digit series of code letters which identified him through the course of the experiment. The codes also identified working shifts and the experimental treatment.

As a preliminary step, a briefing was planned to explain the nature of the project and the role which each firefighter and each experimental treatment would have in arriving at the final results. During the last two weeks of January and the first week of February, the Field Director personally briefed all 30 shifts at the 10 Rockford fire stations. Each firefighter was given a booklet containing the briefing and copies of the prefire planning forms which would be used during the videotape coursework. The firefighter's name was written on the front of the booklet along with his code letters.

Questions about the project were answered at this time to be certain the firefighters understood what

1. This chapter was written principally by John Pachura.

would be expected of them. The stations were also given phone numbers to reach the Field Director if any unusual situations should arise.

Appendices VII-2 through VII-7 detail the information that was given to the firefighters during the briefings. Appendix VII-2 is a general overview of the project which was given to all of the firefighters. Appendices VII-3 through VII-6 are the parts of the briefings which were specifically tailored to the four treatments. Appendix VII-7 explains the pretest.

The two-way system performed extremely well during the field experiment. None of the 138 scheduled one-way and two-way lessons were cancelled due to a total system failure. Occasionally, a terminal or COS failed to work properly, delaying one station, which was rescheduled in the make-up periods.

Pretest

The 27 question pretest was cablecast in the first week of the experiment (February 7-12, 1977). All stations viewed the pretest in a one-way mode, responding to the questions using an answer sheet that was passed out beforehand. Because the pretest results were vital to the experimental design, the following week (February 14-19, 1977) was also used for make-ups of the pretest, which were scheduled on an individual basis for the firefighters who were absent from work the previous week. With the exception of those with long-term injuries, who are released from their duties until they are capable of returning to their companies, all men in the Department took the pretest. The experiment started with a universe of 208 divided among the four treatments.

Two-Way Experience

The week of February 14 also included the initial stages of training the men at the two-way stations to use the interactive terminals. (See Figure 5-1, Chapter 5.) During the briefing sequence, the Field Director had also informed the two-way treatment participants that the bottom bank of the terminal, marked M through X, would be used for video games. A character-generated display told the stations, "PRESS THE RED TRANSMIT BUTTON ON YOUR TERMINAL TO PLAY TIC-TAC-TOE." When a station responded, the computer addressed it individually (i.e., "FIREHOUSE #1, WELCOME TO TIC-TAC-TOE") and gave instructions for the game. The station had the choice of playing X or O and could challenge the computer by placing its mark in the tic-tac-toe board using the following sequence of letters from the bottom bank:

M	N	O
P	Q	R
S	T	U

Interest was added to the game because the computer was programmed to lose if a defined series of moves was made by its opponent at a fire station. Upon winning a game, the computer told the audience "THAT WILL TEACH YOU TO PLAY WITH A COMPUTER." Its losing comment was "HEY, I'M NOT SUPPOSED TO LOSE." Since all of the stations could watch as one station challenged the computer, a feeling of competition developed to see who could find the most ways to beat the computer. In fact, the computer could lose in eight different ways.

February 18-20, the two-way participants were given their final briefing on the use of terminals. The Field Director called the officers on the three shifts at all of the two-way stations and asked them to turn to the project channel. Using a microphone attached to the system, the field director "talked the stations through" the log-in procedures that would be used during the project. Each man entered his code letters in the terminal. If anyone in the audience had a question during this practice, he was advised to call the Field Director immediately. The Field Director sat next to the phone at the control center and answered all questions live over the audio portion of the channel.

It is interesting to note that several of the phone calls were made by the men not for informational purposes, but to hear themselves being addressed over the two-way system.

Each log-in practice lasted about half an hour. The men had the opportunity to log-in a total of four times. The Field Director then again called the officers and ascertained that all of the men on the shift understood the use of the terminals. Satisfied that the firefighters felt comfortable with the technology, the Field Director told the audience to use the same procedure in logging in for the first two-way lesson the following week.

One variation to this procedure occurred. On the final day of log-in practice (February 20), the entire two-way system was ready to be checked out with a programmed lesson. To fully verify the system's readiness, a practice eight-question quiz dealing with fire history was given to the men. The quiz, which did not count as part of the series, ran successfully with men from all four of the two-way sta-

tions. With this experience we concluded that the system was operational.

Video games were available continuously when the channel wasn't being used for lessons.

Other Uses of the System

The cable channel was also used for other purposes. Periodically, the Rockford Fire Academy ran a series of one-way Emergency Medical Technician training tapes to satisfy Illinois state certification requirements. These lessons were scheduled only on days when make-up lessons from the prefire planning series were shown, and only after the interactive lesson was cablecast.

The field office encouraged the firefighters to watch the channel by displaying a series of fire history and trivia questions when no programs were scheduled. The men were directed to phone in the correct answers. A list of all firefighters who answered items correctly for that particular day was compiled and cablecast. The first quiz dealt with the "Great Chicago Fire." Some of the questions asked for information not readily available. For example, one question was "Who was the mayor of Chicago during the fire?" The question was answered quickly by several stations. Later, it was discovered that the research section of the Rockford Public Library had received five calls that day for the information. The calls, of course, came from the fire stations. Different topics were covered during these quizzes and the firefighters became quite competitive in attempting to be first with the correct answer.

As the project progressed, additional interactive games were added to the system's capabilities. The most successful of these was a six-player Blackjack game in which the four interactive fire stations and the cable headend could compete against the computer in its role as "dealer." "Cards" were generated randomly by the computer. Players, in turn, would "hit" or "stay" by pressing one of two buttons on the terminal. The success of this game can be attributed to the fact that all stations were able to play at the same time. Other interactive games involved the computer playing against an individual station. Often, viewers were frustrated in their attempts to be the first to gain access to the system. Interactive Blackjack allowed them to play every time and also to compete against each other as well as the computer.

The first two-way lesson ran on the afternoon of February 21, 1977. All four interactive stations logged into the system and responded during the entire program. The final interactive lesson, discounting make-ups, was cablecast on May 20, 1977. A total of 192 firefighters in all four treatments completed the pretest and posttest, a completion rate of 92 percent. The 16 men who did not complete the series were dropped for the following reasons:

4 men on sick leave during the project.

1 man retired from the Department

6 men were transferred between stations and changed treatment groups.

5 men were on vacation during the latter part of the experiment and were unable to make up all of the lessons before the posttest. (Approximately one-third of the firefighters were on vacation at some point during the project. All were able to make up missed lessons except these five.)

Administrative Differences in the Treatments

Because of the large number of persons, in three shifts, sparsely located over a relatively wide geographical area, the effort required for record-keeping and the accuracy of records varied over the treatments.

During the one-way covert response treatment, officers were asked to take attendance at each session using forms distributed by the Field Director. The system necessitated internal station procedures among the officers of the three shifts for storage of the records and assignment of individuals to take attendance in the absence of an officer. The attendance record was occasionally neglected or incomplete. Although attendance records were checked weekly by the project field office, incomplete or erroneous information was often difficult and time-consuming to track down when discovered. It often took two additional days to correct the record because of the three-day work cycle. Sometimes the records were "pencil-whipped." That is, an officer would indicate for the record that all of the men on his shift viewed all of a particular lesson whether or not they actually did so. At times, the videotape lesson schedule interfered with other station house training, fire inspections, Academy drills or fire calls.

The record-keeping procedures of the one-way, paper-and-pencil treatment produced more reliable results. Each firefighter was given an answer sheet to follow along with the lesson. By filling the code letters at the top of the sheet, a firefighter's presence during the lesson was recorded. However, administrative problems did occur. Frequently, a fire-

fighter neglected to fill in his code letters. If the officer was not in the habit of checking the answer sheets to insure that they were coded, the individual's presence might not be recorded. This means of recordkeeping also required complicated in-station procedures. Answer sheets needed to be stored temporarily at stations. Often there was an accidental destruction or misplacement of the forms. If a firefighter neglected to return his sheet to the officer, or if the officer misplaced the completed answer sheets from his shift, the record was lost. Although these problems occurred infrequently during the project, the record was incomplete. Over a longer period of time and greater number of lessons, the problems would be compounded.

The efficiency of instant computerized recordkeeping displayed advantages in several ways. The two-way group and two-way individual applications allowed daily updating of attendance and lesson scores.

Appendix VII-8 shows a sample printout for one of the interactive lessons. The heading gives the lesson number along with the date and time that the report was generated. Listed along the left hand side of the printout are the code letters of all of the firefighters who had viewed the lesson to that point. The letters next to the codes indicate the manner in which the lesson was viewed; (e.g., L-"loner" or individual; G-as part of a group; S-as "spokesperson" for a group, the one actually pushing the buttons).

The numbers from 1 to 25 sequentially identify the interactive items included in the program. The responses for each individual per item are printed out in the appropriate columns. The far right-hand columns give the lesson scores as raw numbers along with the percentage correct for each individual. The bottom rows of the report constitute an item analysis of each interactive question included in the lesson.

A composite record was also generated by the computer. A sample of this report is included in Appendix VII-9. The left-hand column lists all of the trainees using the two-way system, while the numbers from 2 through 9 and 11 in the top row identify the interactive lessons. Lessons 1, 10 and 12 were administered in a one-way mode. The report gave an overall look at each learner's scores to date and aided with the scheduling of make-up lessons. By finding the blanks in this report, the Field Director was able to reschedule lessons for those who were absent at the primary viewing times.

An additional perspective of the advantages of two-way record-keeping can be gained by contrasting it with current procedures being used in the Rockford Fire Department. The officers on each shift at each station are required to maintain monthly training records for their personnel. Once a month, this record is forwarded, through the deputy chiefs, to the Rockford Fire Training Academy.

At the Academy, an administrative secretary keeps comprehensive records of individual training. Included in these files are evaluations made by Academy officers during annual refresher courses and scores for various exams. Half of the secretary's 40-hour week is devoted to the updating of these records.

Chapter 8

The Training Experiment[1]

Experimental Conditions

The major manipulation in the field experiment was the presence or absence of a digital return capability, using terminals to initiate the digital return. This distinction will be referred to as the TWO-WAY and ONE-WAY conditions. Within each condition response modes were manipulated.

In the two-way condition the two response modes were: (1) a two-way *individual* response treatment, which had one terminal for each participant; and (2) a two-way *group* response treatment in which one terminal served all the participants at selected viewing locations.

Within the one-way condition, the assigned response modes were: (1) *paper and pencil* response, where each firefighter circled answer options on a prepared form, and (2) *covert* response, where participants were instructed to make a mental note of the answer. These interventions yielded the following experimental design:

Experimental Treatments

Two-Way Condition		One-Way Condition	
Group Response Treatment	Individual Response Treatment	Paper and Pencil Response Treatment	Covert Response Treatment

Two-Way Group Treatment

Participants (n = 54) in this condition viewed the videotaped lessons in six groups, varying in size from 6 to 13, using one television receiver and one terminal per group (Figure 8-1). Each time a new lesson was viewed, a *different* group member operated the terminal; after all lessons, each person had operated the terminal at least once. Group members were encouraged to interact with each other about the content of the lessons and the interactive questions during the presentation. When the group had reached a consensus as to the correct answer to an interactive item, the individual operating the terminal initiated the response by pushing the button on the terminal which corresponded to an answer foil appearing on the screen. After the responses from all participants in the two-way conditions had been received, character-generated feedback appeared on the screen in one of the three modes described in Chapter 3. The program was then switched back to the videocassette where the talent provided the correct answer. During the "quick quiz" the group had

Figure 8-1. Participants in the "two-way group" treatment.

only five seconds after the last option appeared to make a selection. Immediately thereafter the scores from the quick quiz appeared by code letter. After the quick quiz was discussed by the narrator, the total scores for the program, including the earlier interactive items and the quick quiz, were presented. This was followed by the cumulative score for the series to date for all two-way condition members of the participating shift. In all of the character-generated feedback for the two-way group treatment the participant-group members within a station received identical information—scores to options selected.

Two-Way Individual Treatment

Participants (n = 50) in this condition also viewed the video lesson in a group setting, but each participant operated his own terminal (Figure 8-2). Participants were encouraged not to talk with each other about the content of the lessons during the presentation, and to come to a solution to each interactive item independently. Once a solution had been reached, each participant entered his own

1. This chapter was written principally by Bradley Greenberg, Nicky Dimitroff and Thomas Baldwin.

Figure 6-2. Participants in "two-way individual" treatment.

response by pushing the appropriate terminal button. The feedback in this condition appeared on the screen by individual code letters. At each lesson's end, participants received character-generated feedback reflecting their individual achievement on the interactive items.

Since both individual and group conditions participated in lessons simultaneously, the feedback on the television screens was a mixture of code letters and responses or scores that represented individual and group behavior. The members of the group condition were able to show slightly better results because individual responses could be checked against the group and corrected, if desired, before transmittal. The average score over all the lessons for participants in the group condition was 90.74; for individual condition participants, 88.44.

One-Way Paper and Pencil Response Treatment

In addition to viewing the lessons in a group setting, each participant in this conditon (n = 54) was given an answer sheet for the interactive items presented in the lessons. Participants were told not to interact with each other about the content of the lessons during the presentation, and each participant independently responded to each interactive item presented. When an answer had been chosen, the participant was instructed to circle the appropriate foil on the answer sheet which corresponded to the foil presented in the lesson. The answer sheets were collected by the company officer after each lesson.

One-Way Covert Response Treatment

Participants (n = 30) in this condition simply viewed the lessons in a group setting. There were nine total groups which varied in size from four to eight men. While participants were asked to make a mental note of the answers to the interactive items, they had no opportunity to *formally* initiate any responses to any of the interactive items. Participants could judge how well they were doing on the series of interactive items by mentally comparing their answers with the answers provided by the narrator. However, at no time were the participants in either one-way treatment provided with feedback indicating how they fared on the series of questions and quick quizzes.

Participants

Participants for the pretest in this study were 208 firefighters from the Rockford Fire Department. The Rockford Fire Department has 11 station houses throughout greater Rockford. All but one were part of the experimental design. Station Number Seven was out of the city limits and not served by cable. The firefighters in that station viewed the tapes, in advance, on a cassette playback machine in their station house and supplied feedback in the formative evaluation process as described in Chapter 4. The Fire Department uses three shifts of firefighters at each station house, with each shift working 24 hours on and 48 hours off. The number of men employed at each station varies from 9 to 24, depending on the specialized equipment necessary to service the particular area. As a result of having to maintain and operate special equipment, firefighters within any one station house possess specialized occupational skills.

While each station within the city limits had a television set connected to cable, not all stations had bi-directional television capabilities. But, the presence or absence of a two-way capability was a function of location, and not staffing. Participants in stations with and without that capability were comparable in education, ranks and years of experience. Within each grouping of stations, station house *shifts* were randomly assigned to response treatments. While station houses were sometimes split among two treatments (e.g., between one-way paper and pencil and one-way covert response), no single shift was ever split between the one- and two-way conditions. Appendix VIII-1 shows the final breakdown of station-shifts to treatment groups, and the number of men in each group.

Instrumentation

Two types of measurement instruments were created to assess the effects of the manipulations:

(1) two **learning** instruments, which were designed to assess the relative comprehension and retention of specific information presented in the lessons, and

(2) two **affective** instruments, which were designed to assess the attitudinal orientation of the individuals participating in the experiment toward various aspects of their learning experience and viewing conditions.

The measurement instruments that were developed will now be described in detail in terms of objectives, development and administration.

The Pre/Post Test

To adequately assess how much immediate learning had taken place within any one experimental condition (relative to all others), a pretest and a posttest were constructed covering the building survey aspects of prefire planning (eight programs). The pretest consisted of 27, four-foil multiple-choice items, with one item tapping each of the 27 behavioral objectives developed for the lessons. (See Appendix VIII-2.) These were 27 of 177 interactive items shown during the videotaped lessons. At the time when these 27 items were selected for the pretest, a set of 22 additional interactive items was also drawn from the 177 items used in the eight programs. These tapped 22 of the same behavioral objectives and were used as part of the posttest. A third set of items also was constructed; one item tapped each of the original 27 behavioral objectives developed for the stimulus. None in this final set of 27 items had been used as interactive items during the programs, but they were designed to be equivalent to the other item sets in terms of content areas tested and degree of difficulty.

The posttest (see Appendix VIII-3) consisted of:

(a) the 27 items which appeared on the pretest,

(b) the 22 items drawn from the remaining set of 150 interactive items not appearing on the pretest, and

(c) the 27 equivalent items which tested material presented in the stimulus tapes, but which had not been used as interactive items.

The items were all transferred to a videotape format most closely resembling a long series of interactive items. This allowed for the simultaneous administration of tests to participants in all conditions. The pretest was administered one week after a three-week period of orientation given to all participants, describing the telecommunication system and other dynamics of the experimental design. The posttest was administered one week after the last of the eight videotapes comprising the prefire planning course was cablecast. This was approximately 18 weeks after the pretest had been administered.

For the pre- and posttests, each participant was given a response sheet (see Appendix VIII-4) which contained the foils of the multiple-choice items in the tests. To respond to any item, the participant circled the letter on the response sheet which corresponded to the item foil.

The Follow-Up Instrument

To adequately assess how much information from the prefire planning course participants in each experimental condition retained over time, a follow-up instrument was constructed. This consisted of the 76 item posttest and interactive items from videotape Program #11. The additional seven items from Lesson #11 tapped two of the 27 behavioral objectives developed for the prefire planning series. These items were specifically created to assess knowledge about the post-survey prefire planning process.

The 76 items repeated from the posttest were administered in their original format, i.e., with the questions appearing in the videotape and the participants responding on individual answer sheets. The seven interactive items chosen from Lesson #11 were transferred to a paper and pencil, multiple-choice test. The follow-up test (see Appendix VIII-5) was administered to all members of the Rockford Fire Department approximately six months after the prefire planning course had ended.

Affective Instruments

Two measurement instruments were created to assess quantitatively the participants' attitudinal orientation toward various aspects of the overall experiment. First, a metric multidimensional instrument was constructed for assessing the participants' attitudinal orientation toward:

(a) the mode of instruction,

(b) the prefire planning content of the videotaped lessons and

(c) the profession of firefighting.

A second affective instrument was constructed to assess the participants' attitudinal orientation toward specific aspects of the viewing conditions. Both the metric multidimensional instrument and the second affective instrument will now be described in greater detail.

The Metric Multidimensional Scaling Instrument

The first step in creating the multidimensional scaling (MDS) instrument, was to generate a series of statements describing the aims, purposes, intentions and implications of the effect of the stimulus on the participants' attitudinal orientations and behaviors. These concepts were then presented to the staff/personnel for examination, critique and comment. Also involved in these sessions were firefighting personnel who were familiar with the vocabulary used by the individuals who would be participants in the experiment. The result of this process yielded a set of concepts which were then cast into the paired-comparison format of the MDS instrument.

The paired comparison format asks the respondent to make comparisons between the selected set of concepts by first, providing a "criterion-pair" which establishes a metric (or ruler) by which judgments can be made, and second, by presenting the respondent with an exhaustive list of all possible two-concept combinations that can be generated from the (original) set of concepts. The questions which appear in the questionnaire are of the following form:

> If A and B are U units apart, how far apart are X and Y?

The "criterion-pair" which was utilized for this particular instrument was arbitrarily created by setting *the difference in meaning* between the concepts *USEFUL* and *ESSENTIAL* as being equal to 100 units. That is, respondents were instructed to consider the *difference in meaning* between the concepts *USEFUL* and *ESSENTIAL* as being equal to a distance of 100 units, and to make their judgments about the similarity or difference (translated into distance) between the other paired concepts on the basis of that "standard."

Three separate MDS instrumen's (see Appendix VIII-6) were embedded in the overall instrument, tapping participants' orientation toward *the mode of instruction*, *the content of the lessons* being presented and *the profession of firefighting* in general. Attitudes toward the profession of firefighting were assessed by having respondents make comparisons between the following set of concepts:

FIREFIGHTING
SAFE
EFFICIENT
PROFESSIONAL
TEAMWORK
SKILLED
ME

Similarly, attitudes toward the content of the videotaped programs were assessed by having respondents make comparisons between the concepts listed below:

PREFIRE PLANNING
ESSENTIAL
USEFUL
TIME CONSUMING
PUBLIC RELATIONS
SAFE COMMUNITY
PROFESSIONAL
BUSY WORK
INSPECTION
ME

Finally, attitudes toward the mode of instruction each participant experienced was assessed by having respondents make comparisons between the following concepts:

TV TRAINING
EFFECTIVE
INTERESTING
DIFFICULT
GOOD
INVOLVING
ME

Semantic Differential Type Scales

In addition to the three MDS instruments, three sets of six-point semantic differential type scales were included in the instrument as secondary indicators of the participants' orientation toward the concepts in the MDS instrument.

There were five scales tapping the participants' attitude toward their profession in general (i.e.):

I think Firefighting is:

Extremely Unsafe	Somewhat Unsafe	Slightly Unsafe	Slightly Safe	Somewhat Safe	Extremely Safe
Extremely Inefficient	Somewhat Inefficient	Slightly Inefficient	Slightly Efficient	Somewhat Efficient	Extremely Efficient

The other scaled concepts were "professional," "skilled" and "team oriented."

There were six scales tapping the participants' orientation toward the prefire planning content of the lessons (i.e.):

I think prefire planning is:

Extremely Essential	Somewhat Essential	Slightly Essential	Slightly Unnecessary	Somewhat Unnecessary	Extremely Unnecessary

The other concepts were "useful," "time consuming," "good public relations," "professional" and "my job."

There were five scales tapping their orientation toward the mode of instruction (i.e.):

I think learning via the training tape is:

Extremely Interesting	Somewhat Interesting	Slightly Interesting	Slightly Boring	Somewhat Boring	Extremely Boring

The other concepts were "effective," "easy," "good" and "involving."

The complete semantic differential instrument is in Appendix VIII-6.

Finally, a set of demographic items tapping age, educational attainment and occupational skill concluded the instrument. All items were screened by the principal investigators and project staff for purposes of clarity and interpretability, before they were included in the instrument.

The attitude instruments described above were administered at five points in time during the course of the experiment. The administration times were:

Time 1: During the orientation period, approximately one week before the pretest was aired.

Time 2: After Lesson #3 had been aired, approximately 6 weeks after the pretest had been aired.

Time 3: After Lesson #6 had been aired, approximately 12 weeks after the pretest had been aired.

Time 4: After Lesson #9 had been aired, approximately 16 weeks after the pretest had been aired.

Time 5: Approximately four weeks after the posttest had been aired, approximately 22 weeks after the pretest had been aired.

The Second Affective Instrument

The second affective instrument (see Appendix VIII-7) was constructed to assess the participants' attitudinal orientation toward various aspects of the viewing conditions, especially the two-way viewing condition. Participants were asked to compare their current learning situation with a potential "live" instructional situation covering the same material and to indicate their communication activity with other participants about the experiment. In addition, participants in the two-way condition were asked to indicate the importance of feedback, e.g., if it was important to know whether or not they were logged-in properly, whether they had responded to an interactive item correctly and how well they compared with other participants. Essentially, these questions were designed to determine the participants' attitudinal orientation toward specific qualities of the interactive mode. The second affective instrument was administered twice, once after Program #8 (approximately 16 weeks after the pretest), and again three weeks after the posttest (approximately 21 weeks after the pretest).

Results

An analysis of variance of the results of the 27 item pretest indicated that there were no significant differences among treatments in the scores firefighters attained on the pretest (see Table 8-1). Each treatment scored an average of 16-17 items correct of the possible total of 27. However, at the time of the posttest, the groups differed significantly in their overall test scores. Table 8-2 shows the treatment scores for the entire posttest ranged from 64 to 69 items correct of the possible 78. All groups scored relatively high on the posttest, but the overall significant difference occurred in the comparison of firefighters in both two-way treatments with firefighters in the one-way covert response treatment.

Table 8-1. Pretest and Posttest Scores on 27 Common Interactive Items by Treatment

	Treatment			
	Two-Way Individual	Two-Way Group	One-Way Paper-Pencil	One-Way Covert
TIME:	(n = 45)	(n = 46)	(n = 52)	(n = 46)*
Pre:*	17.07	16.85	16.48	15.78
Post:*	24.84	24.52	23.88	23.22

*A small attrition in subjects occured in all treatments because of transfer, sick leave and retirement. 192 of theoriaed 208 completed both the pretest and posttest.

*For the pretest, the differences among treatments were not significant ($F = 1.52$, $df = 3/188$, p = n.s.).

*For the posttest, the differences among treatments were significant ($F = 4.65$, $df = 3/188$, $p<.003$). The difference between the two-way individual and one-way covert treatments was significant ($p<.01$, Scheffe).

Table 8-2. Posttest Scores on 78 Items by Treatment

Treatment			
Two-Way Individual	Two-Way Group	One-Way Paper/Pencil	One-Way Covert
(n = 47)	(n = 46)	(n = 54)	(n = 52)
69.02	68.80	66.31	63.85

The differences among treatments are statistically significant. ($F = 10.63$, $df = 3/197$, $p<.001$). The means for each two-way treatment are statistically larger than the mean for the one-way covert treatment ($p<.01$, Scheffe). Tables 8-2 - 8-6 contain all participants who completed the posttest.

Firefighters in the two-way treatments scored significantly higher on the posttest than did firefighters in the one-way covert response treatment.

Separate analyses of variance were computed for each of the three sub-tests which comprised the overall posttest. There were significant differences between firefighters in both two-way treatments and firefighters in the one-way covert response treatment in the scores they obtained on the set of 22 interactive items and the 27 non-interactive items (Tables 8-3 and 8-4). For these two sets of items, there were not significant differences between firefighters in the one-way paper and pencil treatment and firefighters in either two-way treatment.

Table 8-3. Posttest Scores on 22 Interactive Items Not in Pretest by Treatment

Treatments			
Two-Way Individual	Two-Way Group	One-Way Paper/Pencil	One-Way Covert
(n = 47)	(n = 48)	(n = 54)	(n = 52)
20.09	20.33	19.20	18.75

The differences among treatments are statistically significant ($F = 9.57$, $df = 3/197$, $p<.001$). The means for each two-way treatment are statistically larger than the mean for the one-way, covert treatment ($p<.01$, Scheffe).

Table 8-4. Posttest Scores on 27 Unique Items by Treatment

Treatments			
Two-Way Individual	Two-Way Group	One-Way Paper/Pencil	One-Way Covert
(n = 47)	(n = 48)	(n = 54)	(n = 52)
24.09	23.73	23.26	21.85

The differences among means are statistically significant ($F = 8.44$, $df = 3/197$, $p<.001$). The means for each two-way treatment are statistically larger than the mean for the one-way covert treatment ($p<.01$, Scheffe).

Furthermore, Table 8-1 indicates that for the 27 interactive items which appeared on both the pretest and the posttest, there was a significant difference between the firefighters in the two-way individual treatment and firefighters in the one-way covert response treatment. For both the repeated and unique portions of the posttest then, maximum learning occurred among those in the two-way treatments and least learning in the one-way covert response treatment.

To assess more precisely the effects of the manipulations, two regression analyses were performed. These regressions (1) determine if the manipulation accounted for a significant amount of variance in the posttest scores, and (2) determine the relative effect of each learning mode on the posttest score. A set of dummy variables were created by treating each learning condition as a separate variable and assigning arbitrary scores (1,0) for all cases depending upon their presence or absence in each learning condition. Since the dummy variables have arbitrary metric values, they may be treated as interval-level variables and inserted into a regression equation. However, the inclusion of all dummy-coded variables created from a given nominally-scaled variable would render the normal equations unsolvable, since the K^{th} dummy variable is completely determined by the first K-1 dummy variables entered into the regression equation (where K = the number of levels). It is necessary then, to exclude one of the dummy coded variables from the regression equation. However, this exclusion does not result in a loss of information since this variable becomes a "reference category" by which the effects of the other dummy coded variables can be interpreted.

Table 8-5 shows the results obtained from regressing the posttest scores created from the 27 common interactive items on the pretest scores and each of the three dummy coded variables (representing the four conditions). The results of this analysis indicate that a significant amount of variance in the posttest scores is accounted for by these four variables ($F = 11.04$, $df = 4,187$, $p<.001$). The R^2 value, which is

Table 8-5. Regression Coefficients Obtained from Regression of Posttest Scores on Pretest Scores and Experimental Treatments (Dummy Coded 1,0) N = 192

Variable	Unstandardized regression coefficient	Standardized regression coefficient	Standard error	F
Pretest Scores	.26	.35	.49	28.17*
Two-Way Individual Treatment	1.26	.23	.45	8.27*
Two-Way Group Treatment	1.02	.19	.44	5.29*
One-Way Paper/pencil Treatment	.48	.23	.43	1.24
(Constant)	19.10			

$R^2 = .19$

$F(4,187) = 11.04$, $p<.001$

*$p<.01$
*$p<.05$

equivalent to the eta-squared in (conventional) analysis of variance, indicates that 19 percent of the variance in the 27 posttest items is explained by these variables. The relative effect of each learning treatment on the posttest scores is indicated by the unstandardized regression coefficients of the dummy coded variables in Table 8-5. The unstandardized coefficients for both two-way treatments are significant ($F = 8.27$, $p<.01$ for the two-way in-

dividual condition; and $F = 5.29$, $p < .05$ for the two-way group condition). Further, the magnitude of the coefficients for these treatments are 2.67 and 2.13 times greater (respectively) than the coefficient for the one-way paper and pencil treatment (which was not significant). This means that presence or absence of either of the two-way treatments made a significant difference in the score obtained on the posttest.

Utilizing the unstandardized regression coefficients obtained in the regression analysis described above, the predicted posttest scores were calculated and are presented in Table 8-6. The predicted posttest scores (based on the regression) closely match the actual (mean) scores obtained. Utilizing the unstandardized coefficients for each of the dummy coded variables, a new variable (MANIPULATION) was created which incorporated the effects of all treatment conditions. The posttest scores for the 27 common interactive items were then regressed on the pretest scores for those items and the variable MANIPULATION. Table 8-7 indicates that there was a significant amount of variation explained in the posttest scores by the manipulation while linearly controlling for the effect of the pretest. These results permit the following summary in terms of information gain:

Table 8-6. Comparison of Predicted Mean Scores for the Posttest With the Actual Mean Scores Obtained (N = 192)

Treatment	Predicted Score	Obtained Score
Two-Way Individual Treatment	24.67	24.84
Two-Way Group Treatment	24.41	24.52
One-Way Paper/Pencil Treatment	23.87	23.88
One-Way Covert Treatment	23.39	23.22

Table 8-7. Regression Coefficients Obtained from Regression of Posttest Scores on Pretest Scores and the Manipulation (N = 192)

Variable	Unstandardized regression coefficient	Standardized regression coefficient	Standard error	F
Pretest Scores	.28	.35	.49	28.17*
Manipulation	1.00	.21	.32	10.02*
(constant)	19.10			

$R^2 = .19$

$F(2,189) = 22.32$, $p < .001$

*$p < .01$

(1) there were no significant differences among firefighters in any of the treatments in the amount of knowledge they possessed about prefire planning at the beginning of the experiment

(2) there were significant learning differences in the overall posttest scores between firefighters in the two-way treatments and firefighters in the one-way no response treatment

(3) a significant amount of variation in the 27 common interactive items on the posttest was attributable to the intervention (i.e., manipulation) while linearly controlling for participants' performance on the pretest

(4) in terms of learning, participants in both two-way treatments scored significantly higher on the posttest than did participants in the one-way covert response treatment, and higher (but not significantly higher) than participants in the one-way paper and pencil treatment.

The Follow-Up Cognitive Test

Six months later, the posttest was readministered to 196 firefighters to determine learning retention. Added to the 76-item posttest were seven items from Lesson #11, viewed after the original posttest. An analysis of variance of the 83 follow-up test items identified a significant difference among the treatments' test scores. Table 8-8 shows that the treatment scores ranged from 69 to 74 items correct of the possible 83. While all groups averaged better than 83 percent of the items correct, firefighters in the two-way individual treatment scored significantly higher than did individuals in the one-way paper and pencil treatment.

Separate analyses of variance were performed for each of the four sub-sets of items which comprised the follow-up test:

(a) The 27 interactive items which constituted the pretest and also were used on the posttest *(Pre/Post Items)*

(b) The 22 interactive items added to the posttest *(Post-Only Items)*

(c) The 27 equivalent items which were not interactive items in the videolessons but which did appear on the posttest *(Equivalent Items)*

(d) The seven items from Lesson #11 which assessed knowledge about creating and finalizing a prefire plan *(New Items)*

The results of these four analyses of variance appear below and in Table 8-8:

(1) *The Pre/Post Items.* The condition scores ranged from 23 to 24 items correct of the possible 27, with a significant difference between the scores obtained by individuals in the two-way individual treatment and the scores obtained by participants in the one-way paper and pencil treatment. Firefighters in the two-way individual treatment scored slightly (but not significantly) higher on these items than did firefighters in the one-way covert response treatment.

(2) *The Post-Only Items.* The treatment scores ranged from 18 to 20 items correct of the possible 22, with firefighters in the two-way group response scoring significantly higher than firefighters in the one-way paper and pencil response.

(3) *The Equivalent Items.* The treatment scores ranged from 23 to 24 correct out of a possible 27, with no significant differences among the groups.

(4) *The New Items.* The condition scores ranged from four to five correct out of a possible seven. The firefithters in the two-way individual response mode and the one-way covert response made each scored significantly higher on these seven items than did participants in the one-way paper and pencil response.

On the basis of these findings, we feel confident in concluding that there was considerable retention of the information presented six months after the prefire planning series was cablecast, with participants in the two-way condition typically scoring slightly better than participants in the one-way condition. This was especially so for the two-way individual terminal participants.

Affective Results

An affective instrument was administered, first after Lesson #8, and again three weeks after the posttest. This instrument assessed the participants' reactions to the style of instruction they received, and asked them to make comparisons between TV instruction and potential live instruction of the same material. Some questions were asked only in two-way condition and others were asked in both conditions.

Table 8-8. Follow-Up Posttest Scores by Treatment and Item Sub-Sets

Item Subset	Treatment: Two-way Individual (n = 45)	Two-way Group (n = 46)	One-way Paper/Pencil (n = 53)	One-way Covert (n = 50)
Raw scores, 83 items[a]	74.31	72.68	69.68	71.76
Pre/Post, 27 items[b]	24.51	23.90	23.08	23.72
Post-Only, 22 items[c]	19.82	20.21	18.74	19.36
Equivalent, 27 items[d]	24.16	23.50	23.02	23.20
New, 7 items[e]	5.82	5.27	4.85	5.48

[a] The differences among treatments are statistically significant. ($F = 4.37$, $df = 3/192$, $p < .01$). The mean for the two-way individual treatment is statistically larger than the mean for the one-way paper and pencil treatment ($p < .01$; Scheffe).

[b] The differences among treatments are statistically significant. ($F = 2.98$, $df = 3/192$, $p < .05$). The mean for the two-way individual treatment is statistically larger than the mean for the one-way paper and pencil treatment ($p < .05$; Scheffe).

[c] The differences among treatments are statistically significant. ($F = 5.44$, $df = 3/192$, $< .01$). The mean for the two-way group treatment is statistically larger than the mean for the one-way paper and pencil treatment ($p < .01$; Scheffe).

[d] There were no significant differences among the means for this set of items ($F = 1.74$, $df = 3/192$, $p = .16$).

[e] The differences among treatments are statistically significant. ($F = 6.76$, $df = 3/192$, $p < .001$). The means for the two-way individual treatment and the one-way covert treatment are each statistically larger than the mean for the one-way paper and pencil treatment ($p < .05$; Scheffe). These new items came from lesson #11.

Table 8-9 provides the results for questions asked only of those in the two-way group treatment, a total of 42 participants. When this instrument was first administered, each participant had handled the terminal at least once within the group. By the second testing, most group members had handled the terminal twice. Personal satisfaction from handling the terminal increased between the two test administrations, although not significantly. The question they answered specified that "100" was the amount of satisfaction they should consider receiving when not handling the terminal and they were asked to use

Table 8-9. Affective Responses to Terminal in Two-Way Group Treatment

	T_1	T_2	Behrens-Fisher
Times Handled	1.12	1.59	2.35*
Satisfaction	71.30	80.37	1.03
Attentiveness	98.59	100.85	0.22

*$p < .05$

that as a baseline for indicating a figure to reflect how much satisfaction they got when handling the terminal. Both scores at both times were much less than 100, suggesting the firefighters were more satisfied with the televised lessons when they did *not* have the responsibility for handling the terminal in the group situaton. Secondly, they were asked how attentive they were when handling the terminal compared to when they were not (against a baseline of "100"). Although there were no changes between the two testing periods, the average scores at each time indicate they were as attentive to the information when handling the terminal as when not.

Table 8-10 summarizes the results of a set of affective questions administered in both two-way treatments. Logging in was more important initially to those in the two-way individual treatment than it was to those in the two-way group treatment ($p<.05$) and it increased over time for the former, while decreasing for the latter ($p<.01$). A large majority of firefighters in both two-way treatments at both time periods compared their scores and answers with the other two-way participants. Comparing scores increased from 70 percent who did so at Time 1 to more than 80 percent at Time 2, a substantial, but not statistically significant increase. Satisfaction from getting the questions right was uniformly high (over 90 percent) in both treatments at both testings, and knowing the scores on the quick quizzes was also important to more than three-fourths of the participants, especially two-way individual participants.

Table 8-10. Affective Responses in Two-Way Treatments

	T_1			T_2		
	Individual	Group	(z)	Individual	Group	(z)
Log-in Important	84%	64%	(1.67)*	93%	52%	(3.73)*
Compared Scores	68%	74%	(.50)	81%	81%	(0.0)
Compared Answers	76%	74%	(.17)	65%	76%	(1.00)
Satisfied in Seeing Answers Right	92%	88%	(.33)	91%	93%	(.18)
Important to Know Quiz Scores	80%	76%	(.33)	81%	64%	(1.55)*

*p < .05
*p < .10

In summary, from these two tables, it appears that personal satisfaction from the televised lessons while handling the terminal increased over time, although it remained an extra burden for handlers. Further, it was important for each individual to see his ID code log in, but primarily if it meant that the firefighter was personally identifying himself as the terminal handler for the entire interactive lesson, and not just the log-in itself. There was uniform participation in checking one's own scores against the correct ones, and those of other firefighters.

At both testing sessions, a common set of questions was administered to participants in all four experimental treatments. These results are in Table 8-11. For each question, the participants were to compare their activity to what they believed it would have been like under conditions of live instruction, with live instruction to be considered a score of "100." Row 10a indicates how interesting the participants judged their particular mode of receiving the prefire planning training. At Time 1, the groups were not different. The two-way individual participants had a substantial increase on this measure, such that by Time 2, they showed a near significant difference ($p<.10$) from the other treatments. Row 10b indicates that the interactive items were useful for all groups at both time periods, although they never quite matched the live situation. However, the third item, asking how much they thought they learned compared to live instruction, shows that all treatments believed they learned nearly as much or more than in live instruction. Across all these items, there is a pattern suggesting that maximum interest, utility and perceived learning developed primarily in the two-way individual treatment.

Table 8-11. Comparisons of Instructional Mode With Live Instruction

Compared to Live Instruction	Two-Way Individual		Two-Way Group		One-Way Paper/Pencil		One-Way Covert	
	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2
a. How interesting?	89	106	88	82	84	82	101	83
b. How useful the questions?	82	85	78	71	64	74	73	79
c. How much learned?	104	104	85	94	101	90	105	90

The Results of the MDS Instrument

The results in this section identify the major trends in the data that were apparent after several basic analyses were performed.[1] Two sets of results are reported for each MDS set of concepts: first, substantial changes in the mean distance between the focal concept and each of its attendant attributes (across time and across conditions) are discussed, and second, the results of the unidimensional items created from the set of concepts in each MDS instrument are presented.[2]

Firefighting

Participants compared "firefighting" to the following set of concepts: safe, efficient, professional, teamwork, skilled and me. These major trends were apparent upon examination of the mean distance matrices for each condition across time: (1) By the final testing, participants in the two-way individual treatment evaluated each concept in the set to be closer to the concept of "firefighting" than did participants in any other treatment, with the exception of the concept "safe." (2) For the concept "safe," the two-way individual treatment exhibited the most change (98 units); i.e., from Time 1 to Time 5, the mean distance between the concept "firefighting" and "safe" decreased by 98 units. (3) By the final testing, participants in the two-way group treatment evaluated the concept "firefighting" as being further away from each of the other concepts in this set than did participants in any other treatment. (4) Participants in the least involved group, one-way covert response, showed the smallest variability across time in the judged distance between "firefighting" and these concepts.[3] Appendix VIII-9, Tables 1-6, present the mean distances between "firefighting" and each of the concepts in this set across time and treatments. An analysis of variance of the mean distances for each "focal-pair" indicated that there were no statistically significant differences either across time or treatments in the distances reported by the firefighters except in the following instances: (5) There were significant differences at Time 1 and Time 5 between participants in the two-way individual treatment and the two-way group treatment in their evaluation of the concepts "teamwork" and "firefighting," with participants in the two-way individual treatment perceiving firefighting as being closer to teamwork. (6) There was a significant difference at Time 5 between participants in the two-way individual treatment and the two-way group treatment in the evaluation of the professionalism, efficiency and skill associated with firefighting, with participants in the two-way individual treatment reporting significantly smaller mean distances.

1. These analyses involved the orthogonal decomposition of the scalar-products matrix obtained from the aggregation of individual data by treatment.

2. Differences significant at the .05 level are reflected in this text discussion. The tables contain the exact probability values for those who may want to examine the data for trends at a less conservative level.

3. Appendix IX-8 contains summary information for each MDS set as to grand mean distances and variances within each set.

Prefire Planning

The concept "prefire planning" was compared with the following nine concepts: essential, useful, time consuming, public relations, safe community, busy work, inspection and me. Appendix VIII-9, Tables 7-15, present the mean distances between "prefire planning" and each of the concepts in this set. Upon examination the following trends are evident: (1) By the fifth testing, the mean distances between "prefire planning" and each concept (except "inspection") was smallest in the two-way individual treatment. (A point emphasized in the instruction was that prefire planning and inspection were not the same thing, therefore the distance between "prefire planning" and "inspection" should increase.) (2) Over time, the largest movement toward the concept of "prefire planning" occurred in the two-way individual treatment for the concepts "professional," "safe community," and "time consuming." (3) The largest movement away from the concept of "prefire planning" occured for the participants in the two-way group treatment who evaluated the concept "me" as being 76 units further away at Time 5 than at Time 1. (4) Large decreases in the mean distances between "prefire planning" and "public relations" were found for participants in both two-way conditions. An analysis of variance of the mean distances for each "focal pair" indicated that there were no significant differences either across treatments or across time in firefighters' evaluations except the instances listed below: (5) There was a significant difference at Time 4 between participants in the two-way individual treatment and participants in the one-way paper/pencil treatment in their evaluation of "prefire planning" and "public relations," with the two-way participants evaluating the distance as smaller. While the discrepancy between these two means diminished somewhat at Time 5, the order of the means remained the same. (6) There was a significant difference at Time 5 between participants in the two-way condition with respect to their evaluation of how time-consuming prefire planning was. Participants in the two-way individual treatment perceived prefire planning to be

significantly more time consuming than did participants in the two-way group treatment.

TV Training

The concept TV training was compared with: effective, interesting, difficult, good, involving and me, at four points in time. Since the initial assessment of concepts took place before the firefighters had experienced the TV training, this concept was omitted at that time. Appendix VIII-9, Tables 16-21, present the mean distances between each of the concepts listed above across time and conditions. The initial analyses performed suggest that: (1) For every concept paired with "TV training," the smallest mean distance at the final testing existed for the two-way individual treatment. (2) That positive trend commenced primarily between the first and second assessment and remained stable from that point for all concepts. (3) Whereas the mean distance between "TV training" and "effective" diminished over time for participants in the two-way individual treatment, it increased for the other three treatments. (4) This same pattern characterized the mean distance between "TV training" and "me." (5) By the final testing, the mean distance between "TV training" and "good" was smallest in the two-way individual treatment.

An analysis of variance of the mean distances for each "focal-pair" indicated that there were no significant differences either across time or treatments in the distances reported by firefighters except for the following instances: (6) At time 4, there was a significant difference between participants in the two-way individual treatment and the one-way paper/pencil treatment, with the former evaluating their training as being more involving. (7) There was a significant decrease across time for participants in the two-way individual treatment in their evaluation of the self-concept "me" with reference to "TV training."

The Unidimensional Items

The six-point ordinal scales created from the MDS concepts present a less detailed picture of the attitude changes which occurred during the course of the experiment. Appendix VIII-10, Tables 1-16, yield very few significant differences or even consistent tendencies across treatments and time in participants' evaluation of firefighting, prefire planning and the TV training experience.

Summary of MDS Affective Results

While very few of the comparisons among the mean distances achieve "significance" when subjected to statistical test, these data strongly indicate that by the end of the experiment, participants in the two-way individual treatment more favorably evaluated their profession of firefighting, their TV training experience (by a considerable margin) and the content of the videotapes than did participants in any other treatment. Across the three sets of concepts, participants in the two-way individual treatment consistently reported smaller (Time 5) mean distances for each positive attribute included in the set of concepts. It was anticipated that an effective training program would result in the development of a "positive attitudinal orientation" on the part of the participants toward their profession, the content of the programs and the learning experience itself. While the orientation of participants in the two-way group, one way paper/pencil and one-way covert response tratments is somewhat inconsistent across the three sets of concepts, we feel confident in concluding that their orientation is somewhat favorable toward each of the focal concepts, with the orientation of the participants in the two-way individual treatment being considerably more favorable.

Performance

A final assessment of the effect of the training was an evaluation of field performance. After training, the first 28 prefire plan building surveys were scored for accuracy and completion. A perfect score was 100 points. The average score over the 28 surveys was 91 and the median score was 93.

Most of the errors were of omission; a heading or subheading was left blank. Often this occurred where the item was not applicable, but it was not indicated as such. The lessons did not emphasize a standard response to non-applicable blanks on the survey form. Another failure was to neglect the perimeter area, if observation of the perimeter did not indicate major hazards or buildings. The proper procedure, included in the lessons, is to note such perimeter features as railroad tracks and power lines.

Symbols for diagrams, a major element of the training, were consistently correct. Thirty-five symbols were taught, none of which were known at the beginning of the instruction.

Performance on-the-job is perhaps the best test of the training system. In this case, performance evaluation confirmed the generally high learning levels as measured by the posttest. Because of a number of transfers that mixed the treatment groups, no attempt was made, in the performance test, to differentiate among treatment conditions.

Chapter 9

Cost Analyses[1]

This chapter describes the costs of the two-way system, beginning with the specific application in prefire planning, expanding to the more general case of training in the fire department and concluding with the costs in the cable distribution and return system.

Prefire Planning

Prefire plan feasibility depended first on a determination that the net social benefits of prefire planning were positive, and then on selection of a cost-effective method of prefire planning.

Determining if the net social benefits of prefire planning are indeed positive calls for some type of cost/benefit analysis. If a program task is already being accomplished in some form, the benefits associated with the task achievement are assumed to be positive. Prefire planning is presently conducted in Rockford, but the resources devoted to the task have not been sufficient to make significant progress. Therefore, some discussion of the benefit stemming from the investment of resources in prefire planning is in order.

Benefits

Recent studies conducted in Illinois (1) and Massachusetts (2) identified prefire planning as a top priority in future efforts to combat the rising costs of destructive fire. Likewise, the Chicago Committee on High Rise Buildings concluded that prefire planning was of major importance in dealing with high rise fire problems. (3)

Prefire planning benefits both property owners and firefighters. The principal benefit for firefighters is the greater safety in fighting fires in preplanned buildings. For example, Ralph Patterson, an agricultural engineer in the U.S. Department of Agriculture, suggests that prefire planning could prevent most pesticide related firefighter injuries. (4) Property owners also benefit. In West Hempstead, New York, a fire broke out in the 1½ story millwork shop of a lumberyard, located very close to numerous stacks of lumber and a gas station. By utilization of a prefire plan, all the lumber except the millwork was saved, as was the gas station. (5) Prefire planning is also expected to reduce the total time which elapses between fire ignition and eventual extinguishment (reflex time). (6) Reduction in reflex time should lead to controlling more fires prior to flashover, the critical point for life safety and fire control. This would substantially reduce property losses and firefighter injuries.

In sum, prefire planning provides much of the information necessary to fight fires safely and efficiently. Fire damage and death statistics in the United States suggest the costs of inadequate prefire planning. The net social benefits to be derived from prefire planning would, therefore, appear to be positive if costs of prefire planning are reasonable.

Costs

The task, then, is to cost the logical means of achieving a prefire-planned community. Assuming that prefire planning should be completed quickly, we examine here two options that plan all the major buildings in Rockford in slightly more than two years. One option is to create a team of prefire planning specialists within the department who would work full-time at prefire planning. The other option is to train all line officers and firefighters within the department to develop prefire plans for buildings in or near their own still districts (primary coverage area) as a collateral duty. In order to adequately cost these options, an estimate of the number of buildings involved and the amount of time necessary to conduct a prefire plan was obtained.

Buildings

Buildings were categorized by size and complexity of prefire planning by the Rockford Fire Department. In Table 9-1 below, Rockford buildings in critical need of prefire planning have been identified by type and broken down by number into three distinct size categories. The term "size," as used here, means the size of the prefire planning task. A relatively small chemical plant would be categorized as "large" because of the complexity of prefire planning the building.

1. This chapter was written principally by Thomas Baldwin, Michael Wirth, Robert Yaden and John Bowers.

Table 9-1. Building Identification by Size and Type

Building Type	Number of Buildings Per Size/Complexity Category			
	Large	Medium	Small	TOTAL
Schools (Incl. Colleges)	37	57	0	94
Nursing Homes	0	12	13	25
Restaurants	0	0	180	180
Taverns	0	0	110	110
Theatres	0	0	6	6
Manufacturing Firms	100	335	165	600
Hospitals	3	0	0	3
Nurseries/Child Centers	0	0	70	70
Churches	0	0	112	112
Clubs	0	0	41	41
Apartment Buildings (High Rise)	9	0	0	9
Motels/Hotels	12	25	0	37
TOTAL	161	429	677	1,267

Prefire Plan Time Allocation

The second phase was to determine the amount of time necessary to perform each discrete activity within the prefire plan. The Rockford Fire Department has identified eleven stages in its prefire planning procedure:

(1) **Initial Contact** — Usually made by phone, but in some special cases it is made in person with the building's owner/manager.

(2) **Prefire Plan Survey** — Usually made by a team of three or four men, depending on the complexity of the building.

(3) **Follow-Up Contact** — Normally, a second visit must be arranged with the building's owner/manager.

(4) **Follow-Up Visit** — Usually made to fill in data or re-examine certain features of the building. The entire team will not normally return; only one or two members.

(5) **Vehicle Positioning** — Vehicles are physically positioned around large buildings to check out positions for the initial response plan. (May be combined with step #4.)

(6) **Finalization of Survey** — Placing the survey into a final format for the prefire plan packet.

(7) **Preparing Diagrams** — Diagramming the building(s) and perimeter.

(8) **Initial Reaction Plan** — Officers and selected personnel go over survey diagrams and vehicle positioning reports to prepare a reaction plan.

(9) **Duplication and Distribution** — Duplication and circulation of the prefire plan packet to company personnel.

(10) **Extraction of Pertinent Information** — Companies extract basic information from the packets for use at the company level.

(11) **Finalization of Prefire Plan** — Individual companies write their own plans based on the information in the prefire plan packets.

Estimates on the amount of time necessary to complete each phase of the prefire plan listed above are based on building size and complexity. The actual time in creating any prefire plan is subject to many variables (i.e., type of building, age of building, availability of blueprints, and necessity of return visits). Table 9-2 below shows Rockford Fire department estimates of the time necessary to complete each planning phase and the total time per building size.

Table 9-2. Time Allocation Per Activity and Building Size

Activity	Manhours Per Building Size/Complexity		
	Large	Medium	Small
1. Initial contact	1:00	:15	:05
2. Building survey	32:00	20:00	9:00
3. Follow-up contact	:10	:05	:05
4. Follow-up visit	10:00	6:00	4:00
5. Vehicle positioning	18:00	N/A	N/A
6. Survey finalization	4:00	2:00	1:00
7. Diagram formulation	5:00	3:30	2:00
8. Initial reaction plan	8:00	4:00	1:00
9. Duplication and distribution	4:00	3:00	2:00
10. Information extraction	7:00	5:00	3:00
11. Plan finalization	4:00	2:00	1:00
TOTAL	98:10	45:50	17:10

With this basic information, it was possible to estimate the cost and the time to completion of prefire plans for the designated buildings under the two options.

Option 1: Prefire Planning Specialists

In this option, personnel were assigned to prefire planning full-time. The major cost is the salaries of persons so assigned. We have used a base salary of $18,373 and added 25 percent to cover benefits. The $22,966 total over a 40-hour week is an hourly rate of $11.96.

The specialists would conduct all phases of the survey except diagram preparation (step #7), done by a draftsman, and duplication and distribution (step #9), done by a clerk. The salary used for the draftsmen with benefits is $16,250 (an hourly rate of $8.46), while the salary used for the clerk is $10,000 (an hourly rate of $5.21).

The following projections do not consider additional costs, such as using firefighters to assist in vehicle positioning. It also implicitly assumes that specialist training costs are near zero, since in this situation, most training would be "on the job" from one member of the team to another. Therefore, cost projections for specialists in prefire planning are likely to be minimum costs to the City of Rockford under this planning option. Table 9-3 below shows the projected average costs for prefire planning, per activity and building size.

The costs listed in Table 9-3 are projected over all 1,267 buildings listed in Table 9-1. The minimum costs for a full-time specialist, prefire planning 1,267 buildings, is presented in Table 9-4 below.

Table 9-3. Projected Costs Per Activity and Building Size

Activity	Time and Costs Per Building Size					
	LARGE		MEDIUM		SMALL	
	Hours	Cost	Hours	Cost	Hours	Cost
1. Initial contact	1:00	$ 11.96	:15	$ 2.99	:05	$ .99
2. Building survey	32:00	382.72	20:00	239.20	9:00	107.64
3. Follow-up contact	:10	1.99	:05	.99	:05	.99
4. Follow-up visit	16:00	191.36	6:00	71.76	4:00	47.84
5. Vehicle positioning	18:00	215.28	N/A	N/A	N/A	N/A
6. Survey finalization	4:00	47.84	2:00	23.92	1:00	11.96
7. Diagram formulation	5:00	42.30	3:30	29.61	2:00	16.92
8. Initial reaction plan	6:00	71.76	4:00	47.84	1:00	11.96
9. Duplication and distribution[a]	4:00	20.84	3:00	15.63	2:00	10.42
10. Information extraction	7:00	83.72	5:00	59.80	3:00	35.88
11. Plan finalization	4:00	47.84	2:00	23.92	1:00	11.96
TOTAL	98.10	1,117.61	5:50	515.66	17:10	256.56

[a]Clerk's salary used to project these costs.

Table 9-4. Minimum Costs for Full-Time Prefire Planning Specialists, Planning 1,267 Critical Buildings

Building Size	Number of Buildings	x	Costs Per Building	=	Total Cost Per Building Size
LARGE	161		$1,118		$179,998
MEDIUM	429		516		221,364
SMALL	677		257		173,989
TOTAL	1,267				$575,351

Option 2: Collateral Duty for All Station Personnel

If all station personnel participate in the prefire planning of buildings in their own still districts, as a collateral duty assignment, the major costs are: (1) training personnel in the appropriate tasks, (2) diagram formulation and (3) duplication and distribution of plans. This assumes that the time for prefire planning tasks can be spared from other duties without paid replacement (or in other words at zero opportunity cost).

Training Costs

Of these three cost elements, only the training costs remain to be calculated. Because the training took place in four different experimental treatments, we present a cost for each as if all 200 firefighters were trained by that method. In addition we have estimated costs for three other training methods--auto-tutorial, lecture at the Training Academy and lecture at the fire stations.

The auto-tutorial method costs were based on a videocassette playback machine bicycled from station to station. The cassettes would be identical to those used in the experimental treatments.

The lecture at the Academy is assumed to be a well-designed series with slides and graphic components comparable to those used in the television programs of the experiment.

The lecture at fire stations is the same as the lecture at the Academy, except that the lecturer, with visuals and equipment, moves from station to station.

All three of these methods are used on occasion by the Rockford Fire Department and constitute the major training alternatives. Overall, the seven training options present a comparison of the more capital-intensive training methods (e.g., two-way individual) to more labor-intensive approaches (e.g., lecture at the stations).

Tables 9-5 through 9-12 provide a look at the costs of training firefighters to conduct prefire plans under the seven training options. The first four tables (9-5 through 9-8) are based on costs incurred in training firefighters in Rockford projected over the training of all firefighters by each of the methods. Because of the continuing need to train new firefighters and provide refresher training for the others, the costs are provided for reruns of the material: every two years for all personnel. If the life of the series is twelve years, six runs can be made.

Tables 9-9 through 9-12 project the costs over a group of 1,000 trainees. This gives an indication of costs for a larger department.

Table 9-5. Cost of Cable Training 200 Firefighters in 10 Stations in a 12-Lesson Series Originally Produced by the Fire Department Compared to Auto-Tutorial and High Quality, Visualized Lectures. (See notes to Tables 9-5 through 9-12 at the end of this Chapter.)

Item	Cable						
	Two-way individual	Two-way group	One-way paper/pencil	One-way covert	Auto-tutorial	Lecture Academy	Lecture Station
Development and production or procurement	$69,122 (8)	$69,122 (8)	$69,122 (8)	$69,122 (8)	$69,122 (8)	$47,982 (10)	$47,982 (10)
Presentation personnel	216 (11)	216 (11)	216 (11)	216 (11)	4,320 (13)	9,504 (13)	11,664 (14)
Presentation equipment	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)
Response processing, feedback and record keeping	7,423 (18)	5,998 (19)	984 (20)	96 (21)	840 (22)	840 (23)	840 (23)
Equipment maintenance	0 (23)	0 (23)	0 (23)	0 (23)	72 (24)	18 (24)	18 (24)
TOTAL	$78,201	$76,776	$71,762	$70,874	$76,154	$58,752	$60,912
Cost per lesson per person	$32.58	$31.99	$29.90	$29.53	$31.73	$24.48	$25.38

Table 9-6. Cost of Cable Training 200 Firefighters in 10 Stations in a 12-Lesson Series with Purchase of Prepackaged Materials Compared to Auto-Tutorial and High Quality, Visualized Lectures.

Item	Cable						
	Two-way individual	Two-way group	One-way paper/pencil	One-way covert	Auto-tutorial	Lecture Academy	Lecture Station
Development and production or procurement	$3,600 (25)	$3,600 (25)	$3,600 (25)	$3,600 (25)	$3,600 (25)	$1,982 (10)	$47,982 (10)
Presentation personnel	216 (11)	216 (11)	216 (11)	216 (11)	4,320 (13)	9,504 (13)	11,664 (14)
Presentation equipment	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)	1,800 (16)	400 (17)	400 (17)
Response processing, feedback and record keeping	7,423 (18)	5,998 (19)	984 (20)	96 (21)	840 (22)	840 (23)	840 (23)
Equipment maintenance	0 (23)	0 (23)	0 (23)	0 (23)	72 (24)	18 (24)	18 (24)
TOTAL	$12,679	$11,254	$6,240	$5,352	$10,632	$58,752	$60,912
Cost per lesson, per person	$3.28	$4.69	$2.60	$2.23	$4.43	$24.48	$25.38

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Table 9-7. Average Series Cost of Cable Training 200 Firefighters in 10 Stations in a 12-Lesson Series Originally Produced by the Fire Department with Six Repetitions over a Period of 12 Years Compared to Auto-Tutorial and High Quality, Visualized Lectures.

Item	Cable						
	Two-way individual	Two-way group	One-way paper/pencil	One-way covert	Auto-tutorial	Lecture Academy	Lecture Station
Development and production or procurement	$11,520 (26)	$11,520 (26)	$11,520 (26)	$11,520(26)	$11,520 (26)	$7,000 (27)	$7,000 (27)
Presentation personnel	216 (11)	216 (11)	216 (11)	216 (11)	4,320 (12)	4,680 (13)	4,752 (14)
Presentation equipment	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)	1,800 (16)	400 (17)	400 (17)
Response processing, feedback and record keeping	7,423 (18)	5,000 (19)	984 (20)	96 (21)	840 (22)	840 (22)	840 (22)
Equipment maintenance	0 (23)	0 (23)	0 (23)	0 (23)	72 (24)	16 (24)	16 (24)
TOTAL	$20,599	$18,176	$14,160	$13,372	$18,552	$13,935	$14,007
Cost per lesson, per person	$8.58	$7.99	$5.90	$5.53	$7.73	$5.81	$5.84

Table 9-8. Average Series Cost of Cable Training 200 Firefighters in 10 Stations in a 12-Lesson Series with Purchase of Prepackaged Materials with Six Repetitions over a Period of 12 Years Compared to Auto-Tutorial and High Quality, Visualized Lectures.

Item	Cable						
	Two-way individual	Two-way group	One-way paper/pencil	One-way covert	Auto-tutorial	Lecture Academy	Lecture Station
Development and production or procurement	$600 (26)	$600 (26)	$600 (26)	$600 (26)	$600 (26)	$7,000 (27)	$7,000 (27)
Presentation personnel	216 (11)	216 (11)	216 (11)	216 (11)	4,320 (12)	4,680 (13)	4,752 (14)
Presentation equipment	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)	1,800 (16)	400 (17)	400 (17)
Response processing, feedback and record keeping	7,423 (18)	5,000 (19)	984 (20)	96 (21)	840 (22)	840 (22)	840 (22)
Equipment maintenance	0 (23)	0 (23)	0 (23)	0 (23)	72 (24)	16 (24)	16 (24)
TOTAL	$9,679	$8,256	$3,240	$2,352	$7,632	$13,935	$14,007
Cost per lesson, per person	$4.03	$3.44	$1.35	$.98	$3.18	$5.81	$5.84

Table 9-9. Cost of Cable Training 1,000 Firefighters in 50 Stations in a 12-Lesson Series Originally Produced by the Fire Department Compared to Auto-Tutorial and High Quality, Visualized Lectures.

Item	Cable						
	Two-way individual	Two-way group	One-way paper/pencil	One-way covert	Auto-tutorial	Lecture Academy	Lecture Station
Development and production or procurement	$69,122 (6)	$69,122 (6)	$69,122 (6)	$69,122 (6)	$69,122 (6)	$47,862 (10)	$47,862 (10)
Presentation personnel	216 (11)	216 (11)	216 (11)	216 (11)	21,600 (28)	47,520 (30)	50,320 (31)
Presentation equipment	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)	9,000 (32)	2,000 (17)	2,000 (17)
Response processing, feedback and record keeping	14,123 (33)	6,000 (34)	4,440 (35)	396 (36)	3,720 (37)	3,720 (37)	3,720 (37)
Equipment maintenance	0 (23)	0 (23)	0 (23)	0 (23)	360 (24)	80 (24)	80 (24)
TOTAL	$84,901	$77,776	$75,218	$71,162	$103,802	$101,312	112,112
Cost per lesson, per person	$7.08	$6.48	$6.27	$5.93	$8.65	$8.44	$9.34

Table 9-10. Cost of Cable Training 1,000 Firefighters in 50 Stations in a 12-Lesson Series with Purchase of Prepackaged Materials Compared to Auto-Tutorial and High Quality, Visualized Lectures.

	Cable						
Item	Two-way individual	Two-way group	One-way paper/pencil	One-way covert	Auto-tutorial	Lecture Academy	Lecture Station
Development and production or procurement	$3,600 (20)	$3,600 (20)	$3,600 (20)	$3,600 (20)	$3,600 (20)	$47,992 (10)	$47,992 (10)
Presentation personnel	216 (1	216 (11)	216 (11)	216 (11)	21,600 (30)	47,520 (30)	58,320 (31)
Presentation equipment	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)	9,000 (32)	2,000 (17)	2,000 (17)
Response processing, feedback and record keeping	14,123 (33)	6,998 (34)	4,440 (35)	304 (30)	3,720 (37)	3,720 (37)	3,720 (37)
Equipment maintenance	0 (23)	0 (23)	0 (23)	0 (23)	360 (24)	80 (24)	80 (24)
TOTAL	$19,379	$12,254	$9,696	$5,640	$39,280	$101,312	$112,112
Cost per lesson, per person	$1.61	$1.02	$.81	$.50	$3.19	$8.44	$9.34

Table 9-11. Average Series Cost of Cable Training 1,000 Firefighters in 50 Stations in a 12-Lesson Series Originally Produced Within the Fire Department with Six Repetitions Over a Period of 12 Years Compared to Auto-Tutorial and High Quality, Visualized Lectures.

	Cable						
Item	Two-way individual	Two-way group	One-way paper/pencil	One-way covert	Auto-tutorial	Lecture Academy	Lecture Station
Development and production or procurement	$11,520 (20)	$11,520 (20)	$11,520 (20)	$11,520 (20)	$11,520 (20)	$7,000 (27)	$7,000 (27)
Presentation personnel	216 (11)	216 (11)	216 (11)	216 (11)	21,600 (30)	47,520 (30)	58,320 (31)
Presentation equipment	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)	9,000 (32)	2,000 (17)	2,000 (17)
Response processing, feedback and record keeping	14,123 (33)	6,998 (34)	4,440 (35)	304 (30)	3,720 (37)	3,720 (37)	3,720 (37)
Equipment maintenance	0 (23)	0 (23)	0 (23)	0 (23)	360 (21)	80 (21)	80 (21)
TOTAL	$27,299	$20,174	$17,616	$13,500	$46,200	$61,319	$72,119
Cost per lesson, per person	$2.28	$1.68	$1.47	$1.13	$3.85	$5.11	$6.01

Table 9-12. Average Series Cost of Cable Training 1,000 Firefighters in 50 Stations in a 12-Lesson Series With Purchase of Prepackaged Materials with Six Repetitions Over a Period of 12 Years Compared to Auto-Tutorial and High Quality, Visualized Lectures.

	Cable						
Item	Two-way individual	Two-way group	One-way paper/pencil	One-way covert	Auto-tutorial	Lecture Academy	Lecture Station
Development and production or procurement	$600 (20)	$600 (20)	$600 (20)	$600 (20)	$600 (20)	$7,000 (27)	$7,000 (27)
Presentation personnel	216 (11)	216 (11)	216 (11)	216 (11)	21,600 (30)	47,520 (30)	58,320 (31)
Presentation equipment	1,440 (15)	1,440 (15)	1,440 (15)	1,440 (15)	9,000 (32)	2,000 (17)	2,000 (17)
Response processing, feedback and record keeping	14,123 (33)	6,998 (34)	4,440 (35)	304 (30)	3,720 (37)	3,720 (37)	3,720 (37)
Equipment maintenance	0 (23)	0 (23)	0 (23)	0 (23)	360 (24)	80 (24)	80 (24)
TOTAL	$17,185	$9,254	$6,696	$2,640	$35,280	$61,319	$72,119
Cost per lesson, per person	$1.38	$.77	$.56	$.22	$2.94	$5.11	$6.01

Assumptions

Some basic assumptions were necessary to make the calculations. In comparing the actual costs of cable training with estimated costs for auto-tutorial and lectures, it was assumed that the quality of the lectures and audio-tutorial videotapes were equivalent to the videotapes used in cable-delivered instruction. In the case of auto-tutorial, the same tapes could be used so the development and production costs would be identical. For the lectures, the same investment would be made in researching and writing the lectures as in the preparation of the scripts for television. The visuals—slides, films and graphics—used in the lectures would be essentially the same as those used to make the videotapes; therefore the costs would be the same. The only difference between lecture and cable in development and production costs, then, would be the studio and post production costs.

The weakest element of the comparison is in the cost of "response processing, feedback and record keeping." This is relatively easy to calculate for one-way television, auto-tutorial and lecture, but involves the costing of the two-way cable system for the two-way cable instructional methods. Fortunately, Rockford Cablevision has a "System Lease Plan" which prices two-way services. (7) Some of the services involved in the experiments were not priced, since the equipment and the service were unique to the experiments. However, the rationale for pricing service is included in the "System Lease Plan." The lease price for headend equipment is calculated at one-thirty-sixth of the original cost of the equipment per month. The lease price for the terminals is one-eighteenth of the original cost per month. Customer terminal equipment is priced higher than the equipment that remains in the hands of the company. This is a conventional pricing scheme. However, it assumes that firefighter training would be the only service and provide the only return on the capital investment and operational expenses. Other users, and potential users, have emerged who might share in covering these costs, reducing the charge to the Fire Department. Assigning *all* costs to the Fire Department training applications is the most conservative approach.

Whether or not the Rockford Cablevision "System Lease Plan" price list is realistic, requires further experience. The company has regular lessees of data channels, but certainly not in sufficient numbers nor with the variety of different demands on the two-way system to fully test the market and the pricing plan. The best that can be said is that the "System Lease Plan" is a rational plan for a beginning, absent more experience with the market and the technical performance of the system.[1]

The precise means of determining each cost figure in the tables is indicated by footnote. The "bottom line" in the tables is the cost per lesson per person. This seems to be a more comprehensible figure than the total cost for the lesson series.

Cost Comparisons, 200 Firefighter Department

For the Rockford Fire Department, or comparably sized departments, training costs for cable and auto-tutorial methods are higher than lectures at the Academy or in the stations when the videotape materials for cable and auto-tutorial are produced professionally in color. (See Table 9-5.) However, if these video materials are produced elsewhere and purchased by the Department, the costs of cable and auto-tutorial instruction are only about one-fifth the cost of lectures. (Table 9-6.) When lessons are repeated often (e.g., every two years in these calculations), the costs are substantially reduced for department-produced lesson, and one-way cable instruction becomes less costly than lectures because "presentation personnel" costs are much lower. (Table 9-7) When video materials are purchased from outside, the costs of all cable methods and the auto-tutorial method are less than lectures prepared and delivered by Rockford Fire Department personnel. (Table 9-8)

In all cases, two-way cable instruction costs more than one-way television with the one-way, covert response method least expensive. This, however, was also the least effective teaching method of the four cable methods. Two-way cable is from two to three times as expensive as one-way cable. Nonetheless, for this most effective cable method, the cost is as low as $3.44 per lesson per person. The lowest cost for the lecture method is $5.81. It might be more fair to compare two-way cable to lectures than one-way cable, since the questioning and feedback in two-way cable serves as a substitute for the live instructor.

Two-way cable with individual terminals for each trainee is only slightly more expensive than two-way cable with one terminal per station. Although learning was not affected by this difference, the clear preference of firefighters for the individual terminals might justify the small additional expense.

It should be re-emphasized that the two-way costs (detailed in notes 18 and 19 for the 200-firefighter

1. It should be noted that, for the experiments, there were no charges to the Fire Department.

city and notes 33 and 34 for the 1,000-firefighter city) are the most conservative possible. These costs assume the firefighter training application, in itself, pays for terminal and all headend capital and operating costs.

Cost Comparisons, 1,000 Firefighter Department

For the larger fire department, with 1,000 firefighters, even with the cost of producing video materials internally for use on cable, the cost is about one-third less than lectures. The cost relationships between two-way and one-way are about the same as in the smaller department, but the costs of two-way cable instruction were as low as $.77 per lesson per person.

Cost of Prefire Planning by Station Personnel

The highest cost training method, two-way individual, with originally produced color videotape, for all Rockford firefighters is $78,201. Since diagramming costs will be about $30,968 and duplication/distribution approximately $17,115, the total cost of training all station personnel plus drafting/clerical costs would be $126,284.

Comparison of Prefire Planning Staffing Options

The prefire plan staffing option which proves most cost-effective, obviously should be the one selected by the Rockford Fire Department. Two elements are needed to determine the cost-effectiveness of these staffing options: (1) the costs of each option and (2) an appropriate performance indicator(s). Since the cost data have already been provided, specification of the most important performance indicator(s) is all that remains.

The most important performance indicator would appear to be the time required to complete the prefire plans for the 1,267 priority buildings. It is estimated by the Rockford Fire Department that prefire planning, conducted as collateral duty for all station personnel, would yield finished plans for three buildings per company, per month (45 buildings per month total). This means that all of Rockford's priority buildings would have prefire plans in 28.2 months. To achieve the 28.2 months completion rate, approximately 11 full time specialists would have to be hired. (Since the average building takes 37.2 hours per week to plan, each specialist could be expected to complete one building per week.)

The cost-effectiveness ratios provided in Table 9-13 demonstrate conclusively that training all personnel to develop prefire plans even by the most costly training method, is superior to the team of specialists.

Table 9-13. Cost-Effectiveness Ratios for Alternate Methods of Prefire Plan Staffing

Personnel Options	Cost-Effectiveness Ratios* Performance/Total Costs (costs in 000's)		
1. Specialists	28.2 months / 575.35	=	.049
2. All Personnel	28.2 months / 126.28	=	.223

*The staffing option with the highest cost effectiveness ratio is the preferred option.

Cost Comparison Between One-Way and Two-Way Cable

It is pertinent to the cable operator, and to the cost analysis of two-way cable, to determine the cost differential between a cable system with two-way capacity (amplifier housings capable of accommodating modular additions of return amplifiers) and a cable system with the on-line hardware (return amplifiers, switches and other equipment) in place. We will call this latter case a "two-way ready" system. (38) It is capable of two-way communication with terminals of some sort in the feeder system and a scanning and processing system at the headend. Discussion of the distinction between two-way capacity and two-way ready systems from a public policy frame of reference is in Chapter 10.

Table 9-14 presents the costs per mile, in Rockford, of converting the entire distribution plant, trunk and feeder cable, to a two-way ready system. The conversion cost, including all labor costs, is $826.89 per mile. These costs would be only slightly lower if the system were originally constructed to be two-way ready. Mass production of code operated switch controllers would reduce that cost item, but this would have little impact on the total figure.

Since these costs are for on-line distribution plant only, terminal and headend costs must be added. In the simplest case, where only the trunk cable in the two-way system is used for remote cablecasts, only a modem at the remote location and a modem at the headend are necessary. The cost would be about $2,800. For per-view pay television, the cost of the terminal (as noted in Chapter 2) is about $50. A minicomputer, scanning transceiver and other peripherals at the headend are about $50,000. For the firefighter training experiment, terminals (produced

Table 9-14. Additional Costs per Mile of Cable, to Convert a "Two-Way Capable" System to a "Two-Way Ready" Cable System in Rockford, Illinois[a]

.73 Trunk return amplifiers[b] per mile, at $150	$ 109.50
3.6 Line extender amplifiers[c], at $81	291.60
Labor per mile, return amplifier installation[d]	41.04
Labor per mile, deingressing (average of one hour per amplifier per mile = 4.33 × $22/hour)[e]	95.26
.73 Code operated switch controllers (COS), per mile at $153	111.69
2 End of line oscilators (ELO) per mile, at $18	36.00
2.73 Directional couplers per mile (for COSs and ELOs) at $16	43.68
Modified chassis (filter change in the feeder return section in the motherboard of the trunk amplifier and the addition of a switch) at $55 per modification (.73 × $55)	39.60
Labor, installation of COSs and ELOs	58.52
TOTAL	$ 826.89

[a] The Rockford system is 428 miles with a density of 127 households per mile. The feeder to trunk ratio is about 2.5 to 1.

[b] Average amplifier price (thermal equalizers are in every third amplifier). Filters are already built into trunk amplifier motherboards.

[c] The number of trunk and line extender amplifiers per mile is based on the system average. The total number of trunk amplifiers (312) and line amplifiers (1560) each divided by the system miles (428).

[d] All labor charges include the trip charge which would be eliminated in originally building a two-way ready system.

[e] Actual times for deingressing ranged from 20 minutes to several hours per amplifier location.

in small quantities) were $150. This terminal was also useable as a channel converter. The headend costs were about $65,000. A more elaborate headend, with capacity for per-view pay television, interactive instruction and alarm systems could be as much as $150,000.

Using the Rockford per mile two-way conversion costs in a hypothetical two-way capable 150-mile system, conversion to a two-way ready system would cost $124,034. When this figure is added to $65,000 in two-way headend equipment, the total construction and operationalization cost is $189,034. If this amount were borrowed at 10.5 percent interest, and if the cable system made equal annual payments on the note for 10 years, the system would have to generate an additional $31,423 annually to retire the debt and break even on the capital investment.[1]

Cost estimates for the cable system above do not include any capital expenditure for home terminal devices. In some cases, such as the TOCOM, Inc., system in Woodlands, Texas, the $300 cost of the terminal is borne by the subscriber. In the Columbus "Telecinema" case, the company owns the terminal. The capital outlay for this lower cost terminal, however, is substantially reduced by the $40 deposit which is collected at installation. Since methods of capitalization, terminal technology and services vary significantly, the terminal cost is left out of this analysis.

Operating Costs

Table 9-15 provides a general comparison between the monthly operating expenses of two-way capacity and two-way ready operations. The figures indicate that a two-way ready system's office, overhead and miscellaneous expenses exceed those of a two-way capacity system until each system has approximately 10,000 subscribers. Installation, service and support expense comparisons, however, suggest that the two-way ready costs will always exceed two-way capacity costs. The last expense category provided in Table 9-15 is studio expenses.

Table 9-15. Cost Comparison of One-Way vs. Two-Way Operating Expenses (39)

	Two-Way Capacity ($/Subscriber/Mo)	Two-Way Ready ($/Subscriber/Mo.)
Office, Overhead & Misc. Expenses		
1,000 Subscribers	$11.00	$12.00
2,000 Subscribers	6.10	7.00
3,000 Subscribers	4.20	5.40
7,000 Subscribers	2.50	3.40
10,000 Subscribers	2.20	2.20
Installation, Service & Support Expenses		
1,000 Subscribers	6.20	7.00
2,000 Subscribers	2.50	3.70
3,000 Subscribers	1.60	2.80
7,000 Subscribers	1.10	2.05
10,000 Subscribers	1.10	2.05
Studio Expenses		
1,000 Subscribers	2.60	2.60
2,000 Subscribers	2.10	2.10
3,000 Subscribers	2.00	2.00
7,000 Subscribers	1.60	1.60
10,000 Subscribers	1.40	1.40

Note: Expense figures based on aerial system.

These figures are detailed for purposes of the breakeven analysis in Table 9-16. Studio costs can, of course, vary considerably from system to system. Two-way operating systems are probably more likely to incur significant studio operating costs than are their one-way counterparts. However, for purposes of demonstration, the studio expenses are assumed equal for both system types.

The data presented in Table 9-17 detail the number of subscribers (and total sales revenue)

[1] $31,034 = (annual payment) $\frac{1}{.105} - \frac{1}{.105 \times 1.105^{10}}$

needed to meet operating expenses. When penetration of two-way service is relatively low (25 percent), two-way capacity systems break even sooner than do two-way ready systems. Inspection of Table 9-16 suggests two reasons for this situation: (1) two-way ready systems have somewhat higher monthly fixed costs of operation, and (2) the variable costs per subscriber increase substantially for two-way ready systems until they obtain more than 7,000 subscribers.

Obviously, two-way systems must develop new services, and/or sell those two-way services which presently exist (e.g., alarm monitoring and per-program pay TV) which utilize the system's two-way readiness to make the additional investment profitable. Such new services could also be expected to increase the revenue through the addition of new subscribers to the basic service.

Revenue and expense (operating) projections up to this point have been based on a system offering only the standard home security package (e.g., monitoring smoke detectors, security and medical alarms). Economies might be realized with more services. One example would be per-program pay TV. Table 9-17 compares the monthly costs of operating a per-channel pay operation (one-way) with the costs of operating a per-program system (two-way). Inspection of Table 9-17 suggests that before a pay cable operation can make a direct contribution to system revenues, it must exceed its subscriber break-even point. Once a system goes beyond this point, all revenues represent profit. Since this is true for both per-channel and per-program pay cable, a per-program pay operation would have to result in a significant increase in pay cable revenues, and/or basic cable subscription revenues, for an entrepreneur to select per-program over per-channel pay cable.

Table 9-17. Estimated Costs and Revenues of Pay Cable (43)

Type of Operation	Monthly Costs (44)	Monthly Subscriber Fee	Break-Even Number of Pay Subscribers
Telemation program services (TPS) - stand alone (one-way)	$24,949	$7.87 (45)	3,170
Home Box Office - HBO satellite (one-way)	30,732	7.87	3,905
"Telecinema" - stand alone (two-way)	34,247	9.00 (46)	3,805
"Telecinema" - HBO satellite (two-way)	40,459	9.00	4,495

Conclusion

The preceding discussion suggests that: (1) larger cable systems are more likely to find the initiation of two-way service profitable than are smaller systems; (2) the costs of operating a two-way cable system are more likely to impede initiation of two-way services than are the costs of construction; and (3) over time, new two-way services such as per-program pay cable present the potential to generate profits in excess of those which could be earned by one-way systems.

Table 9-16. Break-Even Analysis of Cable Monthly Operating Expenses

	No. of Subscribers	Expenses: Fixed Costs	Expenses: Variable Costs	Expenses: Total Cost	Total Revenue	Monthly Operating Profit (Loss)	Break-Even Monthly Sales Revenue	Break-Even No. of Subscribers
		$	$	$	$	$		
A. Two-Way Capacity	1,000	13,860 (40)	5,940	19,800	6,720 (41)	(13,080)	119,409 (42)	17,769
	2,000	13,860	7,540	21,400	13,440	(7,960)	31,573	4,608
	3,000	13,860	9,540	23,400	20,160	(3,240)	26,311	3,915
	7,000	13,860	22,540	36,400	47,040	10,640	25,611	3,960
	10,000	13,860	33,140	47,000	67,200	20,200	27,346	4,069
B. Two-Way Ready System/ 25% Two-Way Service Penetration	1,000	15,120	6,480	21,600	7,970	(13,630)	80,877	10,148
	2,000	15,120	10,480	25,600	15,940	(9,660)	44,142	5,539
	3,000	15,120	15,480	30,600	23,910	(6,690)	42,885	5,381
	7,000	15,120	34,230	49,350	55,790	6,440	39,125	4,909
	10,000	15,120	41,380	56,500	69,700	13,200	37,213	4,669
C. Two-Way Ready System/ 50% Two-Way Service Penetration	1,000	15,120	6,480	21,600	9,220	(12,380)	50,878	5,518
	2,000	15,120	10,480	25,600	18,440	(7,160)	35,027	3,799
	3,000	15,120	15,480	30,600	27,660	(2,940)	34,337	3,724
	7,000	15,120	34,230	49,350	64,540	15,190	32,195	3,492
	10,000	15,120	41,380	56,500	92,200	35,700	27,431	2,975
D. Two-Way Ready System/ 70% Two-Way Service Penetration	1,000	15,120	6,480	21,600	10,220	(11,380)	41,317	4,043
	2,000	15,120	10,480	25,600	20,440	(5,160)	31,029	3,036
	3,000	15,120	15,480	30,600	30,660	60	30,534	2,988
	7,000	15,120	34,230	49,350	71,540	22,190	28,992	2,837
	10,000	15,120	41,380	56,500	102,200	45,700	25,407	2,486

Notes — Chapter 9

(1) John F. Cragan, "What Management Courses Do Fire Chiefs Need?" *Fire Chief Magazine*, April 1975.

(2) Maurice A. Donahue, *A Management Development Program for Massachusetts Fire Chiefs*, University of Massachusetts Institute for Government Services, July 1975.

(3) Sherwin P. Asrow and Anthony Vilar, Eds., *Fire Protection of High Rise Buildings*, Proceedings, Illinois Institute of Technology, Chicago, Illinois. Report No. 2, September 1972.

(4) Ralph Patterson, "Prefire Planning Signs Can Avert Pesticide Dangers," *Fire Engineering*, March 1973.

(5) Jerome P. Carney, "Prefire Plan Works at Lumberyard," *Fire Engineering*, September 1975, pp. 37-38.

(6) "Master Fire Protection Plans," *Fire Engineering*, July 1973, pp. 38-40.

(7) Rockford Cablevision, Inc., "System Lease Plan," November 24, 1975.

(8) Production personnel salaries, research and writing, supervisory salaries, film, processing, graphics, videotape, studio production contract, etc. Production $24,025; salaries $45,097.

(9) Since these tapes would be identical to the tapes distributed through the cable system, the production cost is the same.

(10) It is assumed that the same research, planning, writing, and audio-visual aids production costs would be involved in these lessons as in the cable television lessons. The cost is therefore $69,122 less the producer salary for 12 weeks ($3,180), film ($1,000), announcer salary ($1,950), and studio production and editing ($15,000).

(11) Operator to prepare for and monitor video feeds at cable headend for 12 lessons for three shifts with one make-up for each original run. $3/hour.

(12) Cassette playback machine delivery and pick-up to 10 stations for three shifts in each station for 12 lessons and one make-up for each lesson. One- and one-half hours for delivery and pickup to all stations at $4/hour.

(13) Ten stations with three shifts each at the Academy for 12 lessons with one Lieutenant spending two hours per session in preparation and presentation. One make-up offered for all 10 stations together for each shift. $12/hour.

(14) Ten stations with three shifts each in the station house for 12 lessons with one Lieutenant spending two-and-one-half hours in preparation, presentation and travel. One make-up offered for each shift for each lesson at the Academy (2 hours per session). $12/hour.

(15) Rental of playback machine at $20/hour for 72 hours.

(16) Cost of playback machine used exclusively for prefire planning instruction (completely depreciated).

(17) Audiovisual equipment shared with other users (slide, film and overhead projectors, etc.).

(18) Data/voice return channel at $136/monthly lease for three months, headend equipment at 1/36 of cost ($64,075) × three months, 67 terminals at 1/18 of cost ($150 each) × three months. (Rockford Cablevision "System Lease Plan" 11-24-75.)

(19) Data/voice return channel at $136/monthly lease for three months, headend equipment at 1/36 of cost ($64,075) × three months, 10 terminals at 1/18 of cost ($150 each) × three months. (Rockford Cablevision, "System Lease Plan" 11-24-75.)

(20) Preparation of answer forms, delivery and pick up of forms, hand scoring of answers, posting. 200 trainees × 12 lessons × $.30 per answer form. 12 lessons delivery and pick-up at three years per lesson at $4/hour. Administrative supervision, 10 hours at $12/hour.

(21) Final examination and posting for 200 trainees × $.30 per answer form. Delivery and pick-up, three hours at $4/hour. Administrative supervision two hours at $12/hour.

(22) Preparation of answer forms and hand scoring of answers, posting. 200 trainees × 12 lessons × $.30 per answer form. Administrative supervision, 10 hours at $12/hour.

(23) Included in lease price.

(24) One percent per month for four months.

(25) $300/lesson × 12.

(26) $69,122 ÷ 6 (see note 8).

(27) $47,992 ÷ 6 (see note 10).

(28) $300/lesson × 12 ÷ 6.

(29) Cassette playback machine delivery and pick-up to 50 stations for three shifts in each station for 12 lessons and one make-up for each lesson. One-and-one-half hours for delivery and pick-up at $4/hour.

(30) 50 stations with three shifts each for 12 lessons at the Academy with one Lieutenant spending two hours per session in preparation and presentation. Five make-ups offered for all 50 stations for each shift. $12/hour.

(31) 50 stations with three shifts each in the station house for 12 lessons with one Lieutenant spending two-and-one-half hours in preparation, presentation and travel. Five make-ups offered for all 50 stations for each shift. $12/hour.

(32) Cost of five playback machines used exclusively for prefire planning instruction (completely depreciated).

(33) Data/voice return channel at $136/month lease for three months, headend equipment at 1/36 of cost ($64,075) × three months, 335 terminals at 1/18 of cost ($150 each) × three months. (Rockford Cablevision, "System Lease Plan," 11-24-75.)

(34) Data/voice return channel at $1.36/monthly lease for three months, headend equipment at 1/36 of cost ($64,075) × three months, 50 terminals at 1/18 of cost ($150 each) × three months. (Rockford Cablevision, "System Lease Plan," 11-24-75)

(35) Preparation of answer forms, delivery and pick-up of forms, hand scoring of answers, posting. 1000 trainees × 12 lessons × $.30 per answer form. 12 lesson delivery and pick-up at 15 hours per lesson at $4/hour. Administrative supervision, 10 hours at $12/hour.

(36) Final examination and posting for 1,000 trainees × $.30 per answer form. Delivery and pick-up, 15 hours at $4/hour. Administrative supervision two hours at $12/hour.

(37) Preparation of answer forms and hand scoring of answers, posting. 1,000 trainees × 12 lessons × $.30 per answer form. Administrative supervision, 10 hours at $12/hour.

(38) The data provided in this secton have come from four basic sources: John Bowers, Rockford Cablevision, Rockford, Illinois; John Hastings, Systems Engineering Manager, C-COR Electronics, Inc., State College, Pennsylvania; Donald Rozak, General Manager of Woodlands CATV Inc., Woodlands, Texas; Marshall Savage, Marketing Division, RCA Community Television Systems, North Hollywood, California; and Barry Silverstein, Cablenet International Corporation, Sarasota, Florida.

(39) The data provided in this table were obtained from Woodlands, CATV. They were prepared on March 11, 1977, and do not include pay TV expenses. Expense figures cited are those of the cable system alone, and do not include amortization of subscriber equipment (e.g., home terminal at $300, basic home security package at $200, or installation costs at approximately $175 per household).

(40) Fixed costs were obtained by assuming that 70 percent of the office, overhead, miscellaneous, installation, service, support and studio expenses for a 1,000 subscriber system represent typical fixed cost figures which should not vary with system subscriber levels.

(41) Total revenue is computed for the one-way service by multiplying the average subscriber rate ($6.72) by the number of subscribers. In the case of the two-way system, total revenue is calculated by first multiplying the average subscriber rate ($6./2) by the number of basic subscribers, then adding $5 for each subscriber who also uses the two-way service. In this case, the two-way service only includes monitoring smoke detectors, security and medical alarms, and does not include additional revenues possible with per-program pay TV.

(42) The break-even sales level was obtained by using the following formula:

$$\text{Break-Even Sales Level} = \frac{\text{Fixed Costs}}{1 - \text{Variable Costs/Total Sales}}$$

(43) All data are from estimates for a converter-filter two-way in the "Telecinema" system.

(44) All pay cable costs are assumed to be fixed costs with respect to the number of pay subscribers since it is assumed that each subscriber will deposit a sum equal to the depreciated value of the converter. These costs are exclusive of any two-way or one-way system costs.

(45) Paul Kagan, "The Pay TV Newsletter," February 16, 1977. This was the average monthly pay cable rate as of December 31, 1976.

(46) "Telecinema" figures indicate that their average pay subscriber spends approximately $9 per month.

Chapter 10

Public Policy in Two-Way Cable[1]

The study of two-way cable technology in public service applications has identified a number of public policy issues to be faced as two-way services expand and develop. This section presents the background of existing policy in two-way cable communication, identifies definitional problems, suggests policies for the implementation of two-way service and outlines some of the responsibilities of local franchising authorities unique to two-way services, particularly in the area of upstream spectrum allocation.

Federal Rules

The Federal Communication Commission's 1972 Report and Order on *Cable Television Service* (1) established "minimum" channel capacities which included a rule that cable systems in designated major television markets must have two-way communication potential. The FCC required that each cable system "maintain a plant having technical capacity for non-voice return communications." (2) It reasoned that such "two-way communication, even rudimentary in nature, can be useful in a number of ways—for surveys, marketing services, burglar alarm devices, educational feedback, to name but a few." (3)

The Commission held at that time that installation of return communication devices at each subscriber terminal was premature. Its rules were satisfied by construction of cable systems "with the potential of eventually providing return communication without having to engage in time-consuming and costly system rebuilding." The construction of a new system with necessary "amplifiers and passive devices" or "equipment that could be easily altered to provide return service" would meet the requirement. (4)

The specific concern of the FCC was amplified in *Reconsideration of Cable Television Report and Order* (1972) (5) in which the FCC prohibited local franchising authorities from requiring a more sophisticated two-way capacity than prescribed by its regulations "because it is possible that any such requirement will exceed the state of the art or place undue burden on cable operators in this stage of cable development in major markets." (6) FCC approval of plans by a franchising authority requiring the installation of more sophisticated two-way capability was to be granted only in those instances where a "franchising authority has a plan for actual use of a more sophisticated two-way capability and the cable operator can demonstrate its feasibility both practically and economically." (7)

In 1976 the Commission attempted to resolve the question of whether to retain, delete or modify the two-way capacity requirement. (8) In rulemaking proceedings that year, most cable system operators filed comments which favored deletion of the requirement. They argued that it increased construction costs "from 10 to 140 percent" while remaining economically not viable for "at least five years." (9) The Berkeley (California) Community Access Center filed comments which urged the deletion of the requirement in favor of its replacement by a local standard. (10) Retention of the requirement was urged by the Electronic Industries Association, educational authorities, city governments and the Cable Television Information Center. The National Association of Educational Broadcasters contended that "two-way instructive uses continue to develop and assume increased significance in the educational process." (11) The City of Imperial Beach, California, asserted that cities could improve governmental efficiency and reduce operating costs by "sharing data processing and computer time."(12)

The FCC reviewed considerations of costs and public benefits involved in constructing cable systems with two-way capacity. Alluding to the existence of a number of two-way cable experiments, the FCC noted that the general operation of "practical commercial two-way services" had not yet developed and that progress had been slower than anticipated. (13) But the Commission also observed that only modest costs were involved in building a plant with two-way capacity and failure to construct the capacity placed substantial obstacles in the path of two-way development. The possibility of very sub-

1. This chapter was written principally by Thomas Baldwin, Thomas Muth and Judith Saxton.

stantial public benefits persuaded the FCC to retain its "limited requirement" for two-way capacity. Accordingly, cable rules were modified to provide that not only major market cable but any system having 3,500 or more subscribers were required to comply having technical capacity for non-voice return communications." (14) Such systems in major markets which began operations after March 31, 1972, and those outside major markets that commenced operations after March 31, 1977, were required to provide the two-way capacity. All other systems having 3,500 or more subscribers were required to comply by June 21, 1986. (15) However, 3,500 subscriber systems which already met the 20-channel minimum capacity requirement (16) on or before June 21, 1976, were not required to modify their plants to comply with the two-way requirement. (17) In setting the subscriber level at 3,500, the FCC reasoned that "we have acted to exempt smaller, often less profitable systems from complying with our requirements and insured that larger communities will have the benefits associated with expanded channel capacity and the provision of access services." (18)

A major factor in the decision to retain the requirement for larger systems was the developmental "chicken and egg" problem. (19) "If the systems generally do not have the capacity to provide these services, then there is little incentive to develop the services. And if the services are not developed, then there is little incentive to install the capacity. (20)

Jurisdiction in Question

The FCC authority to require two-way capacity is now in question. A recent decision by the U.S. Court of Appeals for the Eighth Circuit has set aside the 1976 channel capacity rules (along with cable equipment and access rules) as beyond FCC jurisdiction. (21)

The decision is primarily directed to defeat FCC cable access channel requirements. (22) However, by way of footnote, the court attacks two-way capacity requirements:

> Jurisdiction to require minimum channel capacity and two-way capacity has not been argued separately from the mandatory access requirement. Channel capacity is apparently necessary to provide access channels. The Commission has linked two-way capacity with the 20-channel requirement in the same regulation, apparently because the cost is lower if such capacity be added when the 20 channels are built. The relationship is not as clear as that of the 20-channel requirement, but to the extent that two-way capacity relates to the "access concept" or that two-way capacity cannot be separated from the 20-channel requirement, it must fall with the 20-channel and other regulations of the 1976 *Report*. (23)

Therefore, because two-way capacity is a part of the channel capacity rule and channel capacity is associated (at least, by the court) with mandatory access, the two-way provision was struck down along with access. If the two-way provision had been separated from the minimum channel capacity rule, it might have been treated differently. The FCC has decided to appeal the decision. (24)

FCC jurisdiction over two-way capacity has been questioned in other cases. The U.S. Court of Appeals for the District of Columbia, in *National Association of Regulatory utility Commissioners (NARUC) v. FCC* (25), found that two-way, non-voice communication did not fall within the jurisdiction of the FCC:

> We therefore conclude that most, if not all, of these uses to which the two-way, non-voice cable capacity is likely to be put, fall under the term "carrier" . . . It appears to us that the substantial bulk of the two-way, non-voice communications expected to be carried over leased access bandwidth will be both intrastate and common carrier in nature. . . The plain meaning of 152 (b) therefore seems to bar the Commission's assertion of a general pre-emptive power over all uses of access bandwidth. (26)

The Court concluded that two-way, non-voice communication was not "ancillary to broadcasting" and thus outside FCC jurisdiction. (27) This point is referenced by the Eighth Circuit decision previously discussed. (28)

More specifically, the NARUC definition established that those non-video, instrastate, two-way services transmitted via Class III and Class IV channels (29) fall outside the purview of the "reasonably ancillary" to broadcasting standard established in the *Southwestern Case* (*9) and within the "instrastate" restrictions imposed under Section 152 (b) of the Communications Act of 1934 (31) and therefore is not under FCC jurisdiction. Under precedent established in cases such as *Head vs. New Mexico Board* (32), and *TV Pix vs. Taylor* (33), state regulation is valid provided uniform federal authority is unneeded or remains unexercised.

The "options paper" on cable prepared by the staff on the U.S. House Subcommittee on Communications has suggested greater state and local authority in cable matters. (34) It is anticipated that one outcome of the Communication Act rewrite, for which the options paper was written, will be the federal deregulation of cable.

The trend in judicial and legislative policy, therefore, is to give jurisdiction over two-way capacity to state or local governments.[1] The exercise of local authority in two-way communication will probably best serve the needs of this emerging communication technology, since services will develop experimentally in a variety of forms in many different locations. Policy innovation at the local level could reflect local needs and specific services. There would be immediate feedback on policy effect and the capability to respond quickly. On the other hand, it would be difficult to impose any meaningful federal standards now without interfering with technical and service innovation.

Need for Clarification of Two-Way Capacity

As discussed earlier, two-way capacity is treated by the FCC as something less than active two-way service. Unless this distinction is clearly understood by franchising authorities, the promise of two-way capacity may be misleading. The FCC view of capacity does not require that the cable system be *operational* in the return mode, but only that it be *capable* of furnishing two-way, non-voice services. This necessitates installation of "certain passive equipment in the system's distribution network and the use of downstream amplifiers which possess minimum second order distortion characteristics." The downstream amplifiers must be contained in a dual housing unit, built to receive a second amplifier, for upstream communications. The second amplifier is not actually installed. [36] Installation of the upstream amplifier would render the system active to transmit two-way communication assuming the installation of subscriber and headend terminal equipment.

Under existing federal rules, due to omission of explicit instructions, each government and cable system is left with the responsibility for making the transition from two-way capacity to active two-way services.

1. The policy and rules of at least one state, New York, currently address two-way capability for cable systems. It is the responsibility of the New York State Commission on Cable Television to "encourage municipalities to negotiate for cable systems with a maximum possible capacity and to promote expanded use of such capacity. In particular, non-broadcast and two-way transmission applications for business and educational purposes are encouraged." [35] One of the on-going programs for the New York Commission is to "assess channel capacity needs in the state and establish system capacity and bidirectional capability standards as necessary." [36] The legislation which created the New York State Commission on Cable Television specifically outlines the duties of the commission regarding two-way cable: "... prescribe standards for the construction and operation of cable television systems, which standards shall be designed to promote ... the construction and operation of systems consistent with the most advanced state of the art ... facilities capable of transmitting signals from subscribers to the cable television company or to other points." [37]

Introducing Provisions for Two-Way Cable

The nature of two-way cable communication is now clear enough so that some guidelines may be suggested for franchising authorities and cable companies anticipating a two-way system.

If it is the intent to write a two-way communication requirement into a franchise agreement, the nature of the two-way communication technology demands that the communication service or services to be provided be specified carefully. Each type of service makes unique demands on the character and technical capacity of the system—at the home terminal, in the distribution plant equipment and at the headend.[2]

At this point is is useful to discuss the categories of service that might be provided by a two-way system. Some services may be wholly the province of *private enterprise* such as per-view pay programs for entertainment. Services such as training firefighters and other civil employees are associated with *government* and of predominant concern to public health, safety and welfare. Services such as fire, burglar and medical alarms, represent consumer and public benefits. The distinctions might be made according to the following scheme.

Consumer services would be defined as entertainment, education, alarms, etc., which are consumed directly by individuals. *Institutional* services are those that are used by private institutions (e.g., interbranch communication by banks and department stores) and by government (e.g., internal communication and training in public safety departments).

These definitions require further refinement in terms of the source of support. Are the services associated primarily with the public or private sector? Where two-way services are primarily associated with the private sector, as is the case with per-view pay entertainment, advertising and electronic games, they may be defined as *consumer-private two-way services*. Where associated with private sector institutions, such as business data transfers, they may be defined as *institutional-private two-way services*.

Services that are principally supported by government may also be divided into consumer and institutional categories. *Consumer-public two-way services* may be defined as those used by the public but involving the government. These might include fire

2. To the extent that the household terminal and the headend equipment can be made modular, new services may be added to those specified with minimum cost.

alarms, education, electronic mail and public recreation type entertainment. *Institutional-public* two-way services would include those services used internally by the government such as firefighter training or civil service education.

	Private	Public
Consumer	Electronic games, etc.	Alarm systems, etc.
Institutional	Data transfer between bank branches, etc.	Firefighter training, etc.

If a franchise authority wished to develop particular two-way services, specification of such services could enter the agreement with the franchisee in at least two ways. One way would be the simple requirement that such a service be available on completion of the construction schedule (or as the system is turned on after each stage of construction). Such a franchise clause would seem to be appropriate for consumer- or institutional-private services where the service specified has been tested operationally and where market experience or projections would assure sufficient revenues to keep the two-way service from becoming a burden to the system or its subscribers.

If a two-way system were required exclusively for government services (institutional-public), the capital cost of the two-way system also could be viewed as socially desirable for the community and treated as a cost of acquiring the privileges in a franchise or as a direct cost to the government. In either case, the potential public benefit of the service would still be weighed against the costs, wherever assessed, in determining whether to include the service in the franchise.

The consumer-public category of two-way service presents special problems. In alarm communication, for example, the general public welfare is enhanced and cost of government service reduced, if alarm communication is available through two-way cable. At the same time the consumer realizes personal benefit. If the alarm communication service is mandated by the government, the franchise or ordinance must contain the two-way provision. If the desire is only to make the service available to those citizens who wish it, then the questions of marketability, cost and general public benefit all weigh in the decision to require a two-way system.

If investigation by the franchising authority identifies general value and also seems to indicate a desired consumer benefit, greater public welfare and/or increased government efficiency, writing a two-way service clause into the franchise would be appropriate. On the other hand, in the absence of strong evidence of the benefits of a service, the franchise could stipulate a field test. This would provide an opportunity for both the operator and the franchising authority to evaluate the benefit of the service without the high cost of completing a two-way system. Although many of the headend costs for a two-way system are fixed, distribution plants in many systems have been built to accommodate a two-way retrofit. The necessary switching hardware within the distribution plant can be added after construction. Thus such a field test would require modification of only a part of the cable system. Although a minimum-cost field test could not provide a random sample of households or geographically dispersed institutional sites, the test area could be designed to provide an economically feasible representation of a potential universe of users. Such a field test has been written into the Syracuse, New York, franchise. Smoke alarms and ambulance and police call buttons will be tested in 1,000 households. (39) The franchise appears to leave the ultimate decision to extend the service to the entire franchise territory to the franchising authority. (40) This is perhaps the best policy, since the franchisee will certainly provide a major input to the evaluation process. To be most cautious, an arbitration arrangement could be specified to resolve differences in interpretation of field test results.

If a franchise authority is reluctant to impose even an experimental field test on a cable fanchisee, it might include a "state-of-the-art" clause in the ordinance or franchise agreement which would require two-way service prior to the end of the franchise period. Criteria by which state-of-the-art technology and service are judged may be hard to come by; however, the burden of establishing two-way cable technology as the state-of-the-art has been eased somewhat by the FCC requirement that systems have two-way capacity. The FCC Rules suggest that two-way service is important and imminent enough to warrant system design to accommodate it. A practical demonstration of a two-way service in other systems should provide impetus for suggesting the activation of the existing capability.

It is possible to set forth conditions which would lead to implementation of two-way service. The aggregation of a particular number of users for various types of two-way service would be an important condition. In aggregating users, the franchising authority may play a developmental role. This role could be particularly important in broadband communication because operators may not, on their own initiative, seek to develop applications of the technology which involve additional, and unique, public responsibility.

Whether a franchising authority can require activation of two-way capacity during the term of a franchise agreement, where activation is opposed by a cable system, varies from one jurisdiction to another. It seems that if the ordinance or legislative action which authorizes the franchise includes a provision for amendment of the franchise, the courts would support reasonable change. If the franchise agreement stands alone without adequate supporting legislation, it may be looked upon as a contractual relationship and change may be more difficult, absent franchisee concurrence. (41)

Responsibilities for Local Government

Two-way cable is inherently a local service. The services to be supplied by such a system may involve agencies of local government (e.g., fire and police departments), entities endowed with a public interest, such as educational institutions, or local businesses.

A local government will have to assume some special burdens as it takes up the issue of cable development. As well as determining the kind of specific services it requires, the community may find it in the public interest to encourage development of community communication services that require advanced technology, a function similar to the FCC responsibility to "study new uses for radio, provide for experimental uses for frequencies and generally encourage the larger and more effective use of radio in the public interest." (42)

A unique responsibility for the local authority stems from the fact that in two-way cable, a variety of public and private services may eventually compete for upstream spectrum space. How the spectrum is allocated to these services is important to all users and potential users. Careful and conservative allocation is more critical as new services are developed and users increase.

At the present stage of development of two-way cable, it is possible to make only a tentative apportionment of spectrum to services. This initial allocation can be flexible, particularly if the transmitting-receiving equipment remains in the hands of the cable system. While the cable system may be in the best position to make the initial spectrum decisions in the developmental period, the franchising authority should reserve the opportunity to review the spectrum plan and lease rates to protect certain public interest users (e.g., in firefighter training, alarm systems, electric power system communication). This is particularly important as competition for upstream spectrum increases.

Finally, the franchise authority and cable system must face the problem of adding new capacity as initial upstream spectrum is fully utilized. This matter is complicated by the high capital cost of changing the split between downstream and upstream signals or adding another cable. In these circumstances, a cable monopolist might forestall the capital cost of adding capacity by controlling demand through the lease rate structure.

The major problem for local authority is how to represent the public interest. On the upstream spectrum allocation and rate issues, perhaps the appropriate procedure is to exercise a right of approval so that a mechanism exists for the franchising authority to become informed of system development and to have the opportunity to express a judgment of public and user interest.

The addition of some two-way cable services (e.g., point-to-point data transmission, electric power system communicaton) clearly establishes those cable services in a domain which is generally encompassed by the traditional concept of "public utility." In these areas, the state government may be of assistance to local authorities in dealing with some of the complexities of franchise supervision. Although state governments have no previous experience in such areas as spectrum allocation, they may collect information as it becomes available and subsequently advise local authorities.

Summary

In this discussion we have attempted to document the history of public policy in two-way cable at federal and state levels and to point out where the developing technology leaves that rudimentary policy wanting.

Beyond establishing a clear meaning for two-way communication via cable, several important issues face franchising authorities; how to include two-way services in the agreement with the franchisee, how to represent the public interest in spectrum allocation and how and when to oversee lease rates. At this stage of development policy makers face the historical problem in the telecommunication field—the need to take policy action while both technology and services are in developmental stages. In this case the problem is significantly different because it is primarily local and must be addressed by each community.

Notes — Chapter 10

(1) *Cable Television Report and Order*, 36 FCC 2d 143, February 2, 1972.

(2) 47 C.F.R. 76. 251(2)(3).

(3) 37 Fed. Reg. No. 30; February 12, 1972, p. 3270.

(4) *Ibid.*

(5) *Reconsideration of Cable Television Report and Order*, 36 FCC 2d 326, June 16, 1972.

(6) *Ibid.* Note 25.

(7) *Ibid.*

(8) Notice *of Proposed Rule Making in Docket 20508*, 53 FCC 2d 782, 764, June 3, 197[illegible].

(9) *Report and Order in Docket 20508*, 59 FCC 2d 294, 308, May 1, 1976.

(10) *Ibid.*

(11) *Ibid.*

(12) *Ibid.* p. 309.

(13) *Ibid.*

(14) 47 C.F.R. 76.252 (a)(2).

(15) 47 C.F.R. 76.252 (b).

(16) 47 C.F.R. 76.252 (a)(1).

(17) 47 C.F.R. 76.252 (b).

(18) 59 FCC 2d 304.

(19) 37 RR 2d, Report 29-22, June 2, 1976, p. 231; 59 FCC 2d 309.

(20) 37 Fed. Reg. No. 30, February 12, 1972, p. 3289; 59 FCC 2d 309-310.

(21) *Midwest Video Corp. v. FCC* [Case No. 76-1406] and *ACLU v. FCC* [Case No. 76-1830], U.S. Court of Appeals for the Eighth Circuit, February 21, 1978 [Cases joined in decision].

(22) The decision makes numerous references to "access rules" and requirements. Although operative decisional phrases allude to "channel capacity, equipment and access rules," the Court's "Conclusion" does not specify beyond these phrases.

(23) *Midwest Video Corp. v. FCC, ACLU v. FCC* [1978] at p. 16 and 17, *footnote 21*.

(24) "The FCC Senses an Opening on Cable Regulation," *Broadcasting*, Vol. 94, #15, April 10, 1978, p. 90-92.

(25) 36 RR 2d 303 (U.S. App. D.C. 1976).

(26) *Ibid.*

(27) *Ibid.*

(28) *Midwest Video v. FCC, ACLU v. FCC* p. 16 and 17, Footnote 21.

(29) 47 C.F.R. 76.5 (bb) *Class III Cable Television Channels.* A signaling path provided by a cable television system to deliver to subscriber terminals signals that are intended for reception by equipment other than a television broadcast receiver or by a television broadcast receiver only when used with auxiliary decoding equipment. (cc) *Class IV Cable Television Channel.* A signaling path provided by a cable television system to transmit signals of any type from a subscriber terminal to another point in the cable television system.

(30) *United States v. Southwestern Cable Co.*, 392 U.S. 157 [1968].

(31) 47 U.S.C. 152 (C).

(32) *Head v. New Mexico Board* 374 U.S. 424 [1963].

(33) *T.V. Fla. Inc. v. Taylor*, 304 F. Supp. 459 [D. Nev. 1968].

(34) Options Papers, prepared by the staff for use of the Subcommittee on Communications of the Committee on Interstate and Foreign Commerce, U.S. House of Representatives, 94th Congress, 1st Session, Committee Print 95-13, May 1977.

(35) New York State Commission on Cable Television; *Telecommunications in New York State: An Agenda for Government Involvement*, Docket No. 90112, May 1977, p. 94.

(36) *Ibid.* p. 95.

(37) New York Executive Law, Article 28: Communication on Cable Television, Section 815(2)(d)(ii)(iv), January 1, 1973.

(38) 53 FCC 2d 782, 793-794.

(39) City of Syracuse Franchise Agreement, 1977, Section VI, "Alarm Systems," 6.2, "Pilot Programs."

(40) *Ibid.* Section 6.3(a), "Alarm System Testing."

(41) 41 ALR 3rd 384, 6, p. 400-404; *City of Liberal v. Teleprompter Cable Service Inc.* 544 p. 2d 330 [1975].

(42) 47 U.S.C. 303 (g).